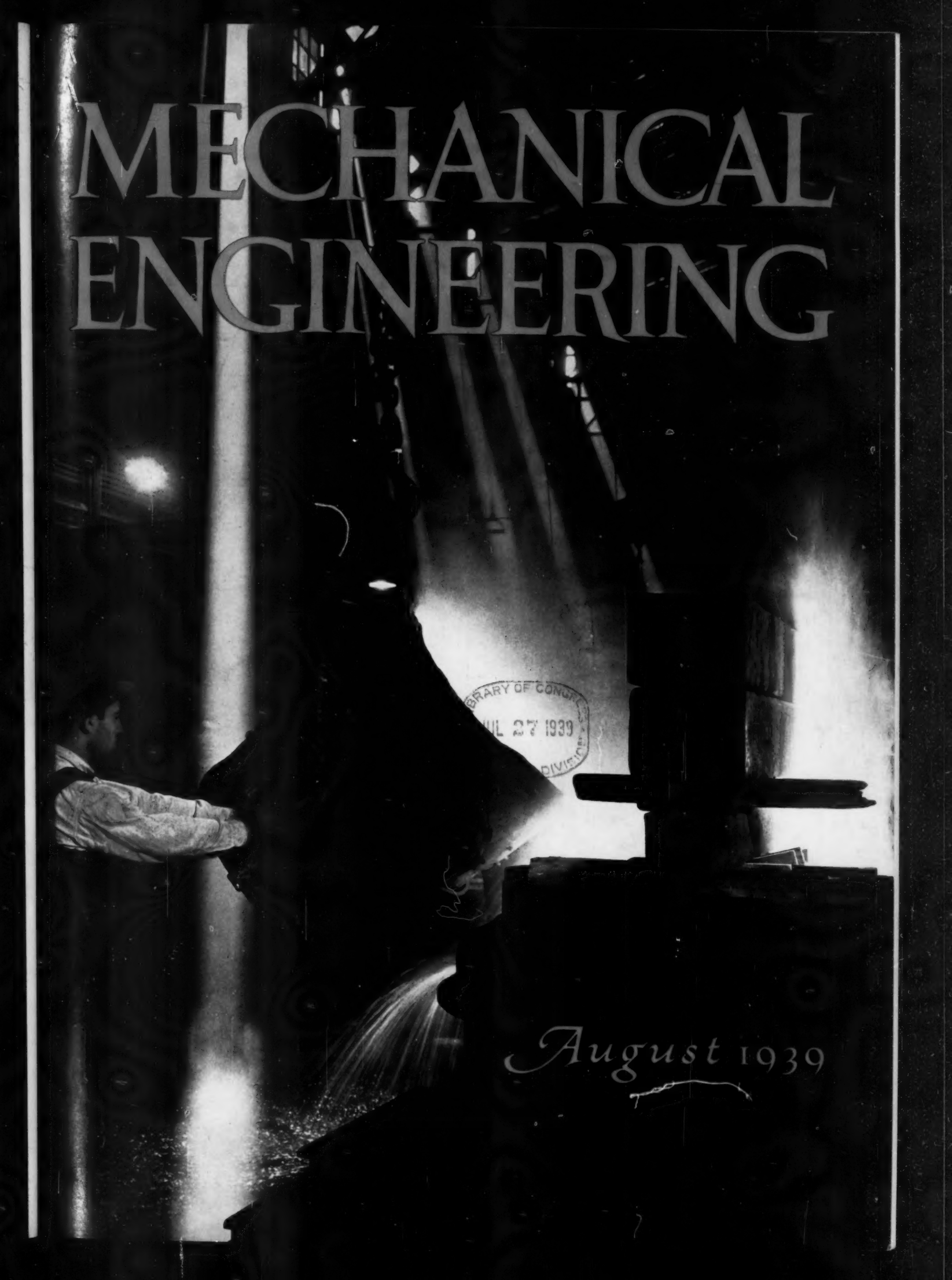
MECHANICAL ENGINEERING



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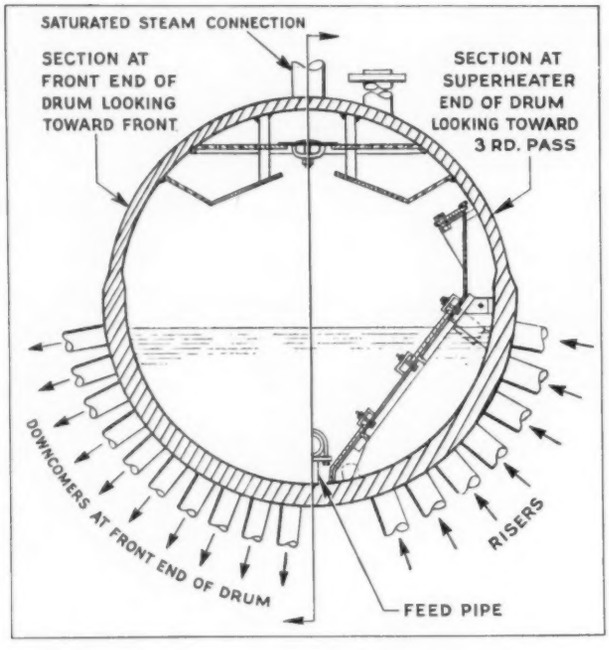
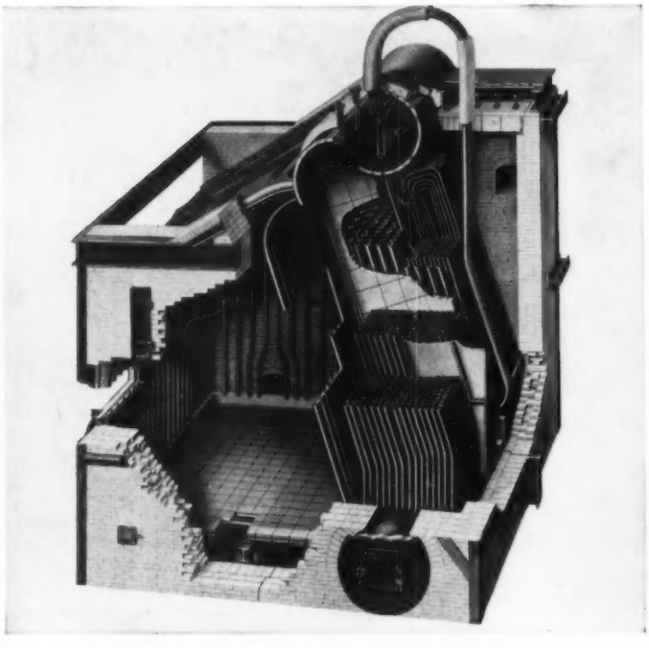
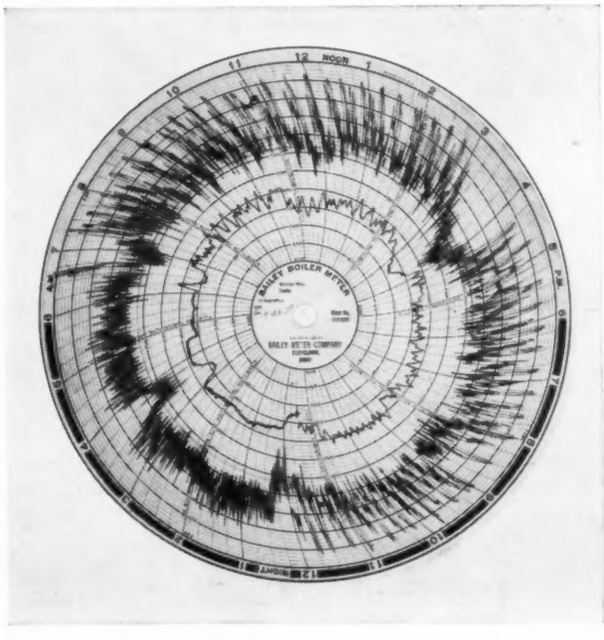
B&W Integral Furnace Boiler

for Steady Water Level *and* Dry Steam


SATURATED STEAM CONNECTION
SECTION AT FRONT END OF DRUM LOOKING TOWARD FRONT
SECTION AT SUPERHEATER END OF DRUM LOOKING TOWARD 3 RD. PASS
DOWNCOMERS AT FRONT END OF DRUM
RISERS
FEED PIPE

Dry Steam and Steady Water-Level, under fluctuating loads, and better circulation assured by compartment baffle. Risers empty into one drum compartment, downcomers are fed from another compartment or zone of little turbulence. Flow to still zone adjustable for specific ratings and concentrations, baffled for removal of entrained water from steam. Has operated successfully with boiler-water concentrations exceeding 6000 p.p.m., with considerably less than 0.5 per cent moisture in the steam delivered to the superheater.





Abrupt load swings are met successfully by the Integral-Furnace Boiler as typified by this chart from a unit of 50,000 lb. per hr. capacity. Such swings are met without harmful moisture or carry-over in the steam.

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Contents for August, 1939

HYDROELECTRIC POWER-PLANT DESIGN . . . . . *A. T. Larned* 575
SOCIAL RELATIONSHIPS AND INDUSTRIAL UNREST . . . . . *Douglas McGregor* 580
POWER AND FUEL . . . . . *E. G. Bailey* 581
BRAKING HIGH-SPEED TRAINS AS AN ENGINEERING PROBLEM—I . . . *J. C. McCune* 583
THE STRENGTH OF METALS AT ELEVATED TEMPERATURES . . . . . *R. F. Miller* 589
COOPERATIVE WORK OF THE A.S.M.E. BOILER CODE COMMITTEE . . . *D. S. Jacobus* 595
MANAGEMENT IN THE SMALL PLANT . . . . . *L. M. Gilbreth* 597
SOME TECHNICAL AND ECONOMIC ASPECTS OF THE ARGENTINE . . . *R. E. Ballester* 599
COAL HYDROGENATION . . . . . *H. H. Storch and A. C. Fieldner* 605

EDITORIAL 573
BRIEFING THE RECORD 612
LETTERS AND COMMENT 618
A.S.M.E. BOILER CODE 623
BOOKS RECEIVED IN LIBRARY . . . 623
A.S.M.E. NEWS 625

INDEX TO ADVERTISERS 36

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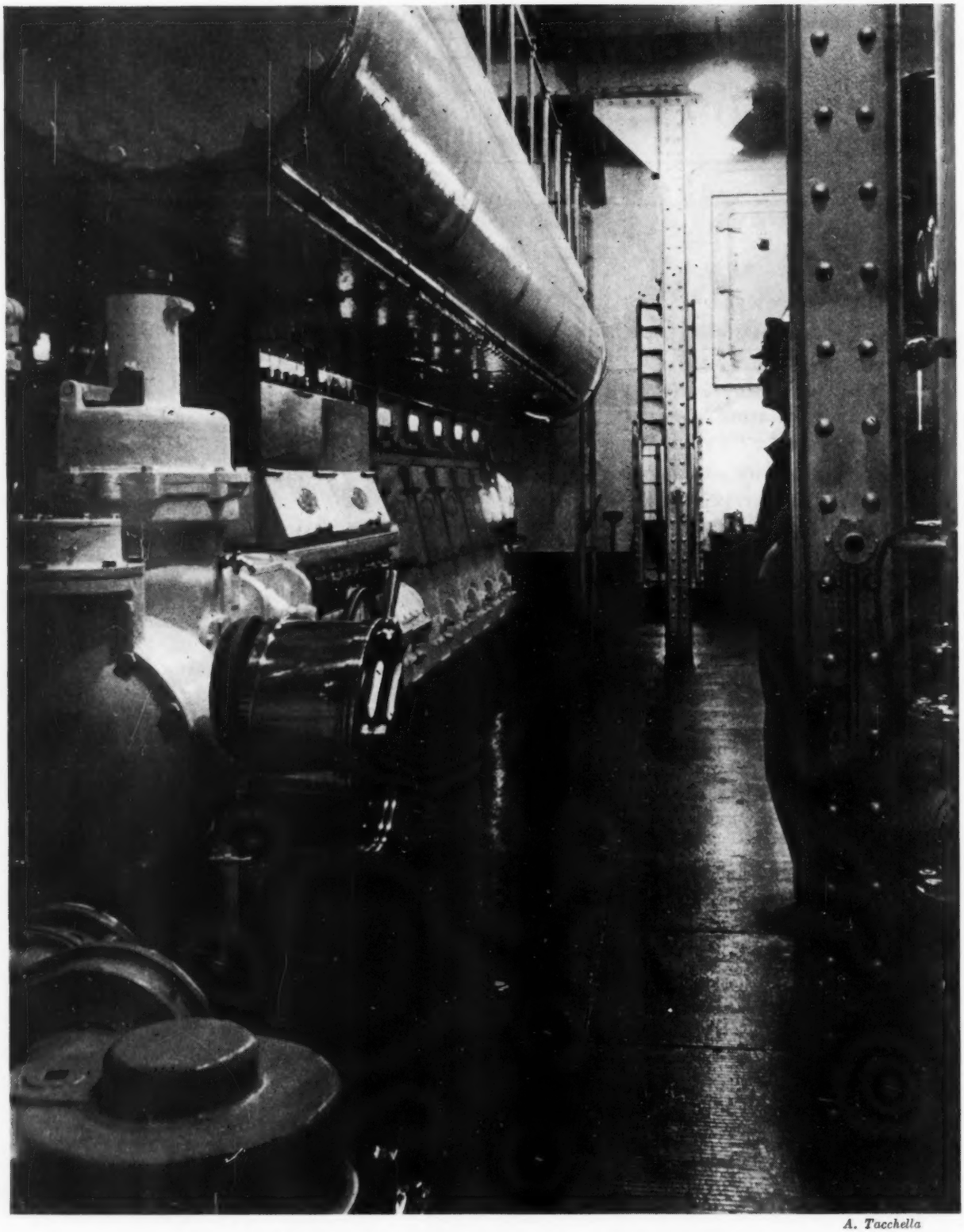


A. Tacchella

Ten-Cylinder 3000-Shp Marine Diesel Engine

(Scene in Engineroom of Streamlined Ferry "Kalakala," that operates between Seattle and Bremerton, Wash.)

VOLUME 61
No. 8

MECHANICAL ENGINEERING

AUGUST
1939

GEORGE A. STETSON, *Editor*

Engineering's Great Task

SINCE the first of the year four eminent engineers have called attention to certain nontechnical aspects of engineering. The addresses of the men referred to include: One by Vannevar Bush, president of the Carnegie Institution of Washington and formerly professor at M.I.T., before the American Engineering Council in January, published in the March, 1939, issue of MECHANICAL ENGINEERING, entitled "The Professional Spirit in Engineering;" another appeared in the July, 1939, issue of *Electrical Engineering* under the title "Some Thoughts on the Social Obligations of Engineers," by John C. Parker, president A.I.E.E., public-utility executive, and former professor of engineering; a third was the presidential address delivered at State College, Pa., by Karl T. Compton, president S.P.E.E. and president of the Massachusetts Institute of Technology, on "Engineering and Social Progress;" and finally there was an address, also presented at the State College meeting, "Social Responsibility of the Engineer," by Robert E. Doherty, president of the Carnegie Institute of Technology, and former associate of the famous Steinmetz at the General Electric Company.

These addresses are by no means pioneer attempts by engineers to discuss social aspects of engineering, as readers of this journal are fully aware. In fact, President Compton began his address by saying, "I sometimes feel, now that engineers have begun to discuss the social aspects of engineering, that we, too, refuse to talk about anything else," although he hastened to add that he was "proud of this new voice in engineering."

That the voice is not altogether new, although its tones have recently acquired a bolder and more earnest ring, is also known to readers; for, as Mr. Parker confessed, as far back as he can remember engineers have questioned "whether it [engineering] was discharging its obligations to society." Although many engineers maintain the point of view expressed by that crusading and lovable character, Sanford A. Moss, in a letter entitled "Back Talk" to be found in the correspondence columns of this issue, the fact remains that discussion of these nonengineering topics has persisted in A.S.M.E. publications for more than 50 years. Indeed, a profession which 100 years ago summed up its services in terms of developing the great sources of power in Nature for the benefit of mankind, could hardly escape discussion of the social and economic implications of its work. Nor has it; and, particularly since the World War, such discussion has increased not only in quantity but in quality and depth of understanding as well. What the effects of such discussion have been it is hard to say; and to measure their value in terms of the cost of printing is quite impossible. We must accept it as a fact, however, that a deep-seated intellectual (some will possibly say emotional) stimulus has acted on the minds of a constantly widening group of engineers. The result has been a pressure put upon engineering journals for space in which many and varied views could be expressed. Regardless of what editors may have on their consciences for what they have published, only they themselves know how real this pressure has been and how many manuscripts are returned to authors.

It is possible to cite many influences that have excited this urge on the part of engineers to think and talk about the nontechnical aspects of their profession. There is, for example, a human desire for self-glorification that leads men to attempt to enhance their prestige and station by reminding their fellows what civilization owes to engineering. Claims to exclusiveness and special privilege are likely to lead, as they have so frequently done in the past, to the practice of economic and social tyrannies. As facts, these achievements have their useful place in history, and as traditions they provide inspiration for professional ethics and ideals. Their social qualities are no more to be denied than their social consequences, whether they derive from the work of men toiling without thought of reward or from business enterprises operating for profit.

Nor should engineers cease emphasizing the importance of their contribution to material progress or of the method of attack on problems that is so characteristically theirs—the scientific method. "Let us lose no chance," said President Compton, "to emphasize that our modern civilization owes its flourishing to the engineering philosophy, the most fruitful intellectual method and outlook in the world's history, and that a misuse of it or a departure from it may easily plunge us into a new dark age. Let us also emphasize that the contribution of engineering has not been limited to engineering accomplishments, important as they have been." And as President Doherty put it, let us pray that "we learn to make practical use of a new power within our reach that generations of history did not have—the power of reasonable prediction that may come from the scientific method if it be applied to social and economic problems with the same intelligence as it has been applied to physical problems."

However, pressure for prestige and economic advantage on grounds of contributions made to man's material welfare is not the only reason for the engineer's interest in his relationship to society. The sense of

social obligation that follows sober consideration of the extent of this relationship is a deep and powerful motive. It embraces acknowledgment of the disturbing influences as well as the material benefits that applied science introduces into men's lives, and it recognizes the destructive as well as the constructive uses that others may make of the techniques developed by engineering and of the opportunities and instruments of oppression that may be seized by unscrupulous persons. An individual searcher after truth and adapter of science to useful ends may find the social balance heavily in his favor and justly accuse the wasteful but inevitable processes of economic evolution or the selfishness of less high-minded persons of the evil consequences that follow in the wake of progress. Employed in the service of others because of his knowledge and skill, however, the engineer may suffer a moral conflict that is most easily rationalized by protesting that he accounts to his conscience and the judgment of the world on the basis of his technical services only, and not on grounds of social obligation. Yet even here the social balance may be in his favor, as Mr. Parker indicated.

Speaking of the great engineers the world remembers and honors, who "represented the search for truth quite unaffected by any slightest element of self-interest," Mr. Parker, in the address referred to, said: "No one will deny that the generations past and to come magnificently have been enriched by their sense of social obligation;" but he also insisted "that in effect the business corporations which engage the services of engineers have been dominated by a realization that a maximum profit for the owners could result only from a broad dissemination of the products, and that this effect has led to a high type of socialization of the work of the engineers." This too, then, is a sense of social obligation of a sort, recognition of which leads to speculation about broader implications.

On this element of social consciousness, undoubtedly, rests the claim of engineers to professional status in its broad sense, and on the pressing of this claim must follow a realization of the obligations it entails, obligations that are not only inherent in the professional ideal itself, but that are also imposed by society. For, as Doctor Bush said in his A.E.C. address, there is one central theme in all professions—"they minister to the people." If any group seeks recognition on the basis of professional status and competence, and as a consequence of that recognition is accorded certain privileges by society, its conduct and that of its members must be truly responsive to the public welfare. Otherwise, in a democracy it is likely to lose both its status and its privileges, for what the people can give they can take away. Some professions face this dilemma today in a very realistic way; and if engineering does not as yet face such a retraction, it is because it is not well defined in the public mind as a profession. "This concept of ministering to the public welfare," said President Compton at State College, " . . . is the remaining principle that needs to be fully synthesized with other elements that have been combined to form the engineering philosophy." "I submit that the future of engineering," he added toward the end of his address, "is largely bound up with this struggle for a true professional spirit, and I submit, further, that engineering's continued contribution to social progress is likewise at stake. If society is to respect the engineer and to permit him to function effectively, it must recognize him as a professional man, animated by the precepts of engineering philosophy, competent and authoritative in his art, and zealous in behalf of the ultimate welfare of the nation."

President Doherty, who reviewed evidence of the "ugly fact . . . that strife and confusion characterize the American scene," confessed "that within my limited view there is little promise of long-range social felicity unless I postulate some new element that is not yet manifest in the body politic." "It seems to me necessary," he said, "that there be a pervasive infiltration among the citizenry, of professional people who will have become socially literate and who feel the responsibility that goes with advantage and privilege; and further that professional groups hold constantly and pre-eminently in view their status as organic units of a democracy now under stress and their responsibility to help save it for future generations."

Engineers, doctors, lawyers, and social scientists cannot do this alone; ". . . no profession can be depended upon alone for judgments that involve interests and factors extending beyond its purview." And since "there is not a superprofession," we are "inevitably committed to the more clumsy but democratic scheme of conference or council for reaching intelligent proposals that the people, or legislative groups, might have confidence in. Thus such councils would provide technical expertness, balance of interests, and the effective joining of boundary connections between related fields of social activity. All these are essential and they cannot be achieved through the policy of professional isolation. The engineer cannot delegate his responsibility to the social scientist."

Both President Compton and President Doherty looked to engineering education as the most hopeful means of awakening consciousness of social obligation in engineers and called upon the teachers of engineering students to provide means by which young men may accustom themselves to an habitual consideration of their chosen profession and its problems. But the effort cannot stop with the engineering schools. The educational experience extends beyond the college into the profession and the professional society. The awakened consciousness of young men must have something to feed on after graduation. The engineering society must help to provide this intellectual sustenance. No greater task lies before it. If engineers do not take up the task they may find that the opportunity to do so will pass into the hands of the public they have failed to consider.

All this suggests a program: Let engineers continue to make contributions to material progress; let them publicize that progress and assist it to advance with a minimum of social and economic distress. Let them preach and demonstrate the scientific method with intelligence and humility. Let them foster the professional spirit and accept its social obligations.

KERR PLANT, MONTANA POWER CO., SHOWING DAM AND POWERHOUSE WITH PROVISION FOR INSTALLATION OF FUTURE UNIT

HYDROELECTRIC POWER-PLANT DESIGN

By A. T. LARNED

PHOENIX ENGINEERING CORPORATION, NEW YORK, N. Y.

IN 1936 at the Niagara Falls meeting of The American Society of Mechanical Engineers, A. C. Clogher, consulting engineer of Ebasco Services Incorporated, presented a paper[1] dealing with hydroelectric practice in the United States from the earliest installation up to that time. This paper elaborated on some of the notable advances in hydraulic design and these have been referred to briefly in this present discussion and supplemented by the developments since this earlier paper was written.

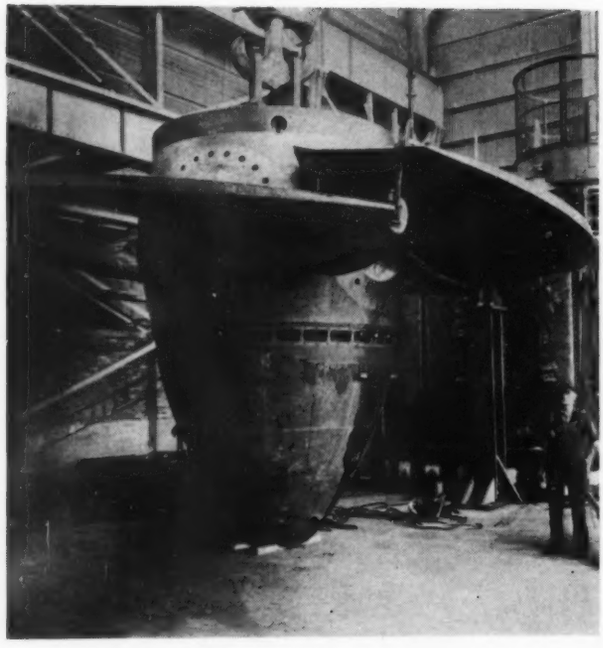
To describe present-day hydroelectric practice adequately would involve a paper of considerable length and detail, since practically all of the various branches of engineering are concerned. To be of interest to mechanical engineers, therefore, it will be necessary merely to "hit the high spots" by briefly outlining the general development of the modern hydroelectric station, its functions in the field of power generation, and some of the more recent notable developments in hydraulic-turbine design.

HYDROELECTRIC PLANTS ORIGINALLY DESIGNED AS ISOLATED UNITS

The problems confronting the designers of hydro stations today are of an entirely different character from those faced by the engineers who designed our early plants. These pioneer developments consisted almost entirely of small isolated plants built by promoters usually with limited financial resources and capable of serving only limited loads and areas. The plant had to be independent, self-regulating, and capable of standing on its own feet. Most of the developments were of the run-of-river type with low dams and reservoirs containing little or no storage capacity. The powerhouses contained a series of low-

[1] "Hydroelectric Practice in the United States," by A. C. Clogher, Trans. A.S.M.E., vol. 59, 1937, pp. 65-77.

Presented at the technical session of the first annual "Spring Round-Up," New York, N. Y., April 20, 1939, of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



SHOP VIEW OF 66,000-HP PROPELLER-TYPE TURBINE RUNNER FOR BONNEVILLE

capacity units almost entirely of the horizontal type—the large number insuring greater reliability of operation.

MODERN PLANT IS A UNIT IN A SYSTEM

The power system of today has been the result of gradual expansion of these small service areas as the region and load developed and the integration of individual plants and systems through the medium of financing groups staffed by technical and service specialists. The consolidation of operating properties into major systems made possible substantial operating economies through diversification in load and power-production sources. Interconnections between these major systems resulted in further reliability and better service to customers by providing reserve and emergency stand-by. Interchange of power between these neighboring systems has also resulted in economies through additional diversification and the utilization of surplus energy.

FUNCTIONS AND POSITION OF HYDRO PLANT IN THE LOAD CURVE

Each generating station in such an interconnected group of systems is now merely a unit feeding into the transmission system in accordance with its capabilities and the characteristics of the load. The combination of hydro and thermal plants in supplying load requirements has proved particularly advantageous. In general, steam plants and run-of-river hydro plants can be operated more economically at higher load factors on the base of the load. The hydro plants with available storage capacity may be utilized to take the peaks of the load at the lower load factors. When water is abundant this procedure is reversed and the hydro units can carry the bulk of the load with a resulting saving in fuel and operating costs in the steam plants.

Usually on an extensive interconnected system, one or more major plants are utilized to regulate the speed of the entire system through the medium of automatic frequency-control equipment. Close frequency control is thereby attainable, which has become a necessity, particularly in systems having textile or paper-mill loads. Correct integration of frequency is also of extreme importance since the advent of electric time keeping. Automatic tie-line control equipment is also used to maintain the scheduled interchange between the systems and at the same time aids in the control of frequency.

The modern hydroelectric station must, therefore, be a component part of the power system of the region and calls for the exercise of considerable judgment and skill on the part of experienced power-plant designers to provide equipment which will allow it to most advantageously fulfill its role. The requirements of an integrated system have a controlling influence on the general design of the station, on the selection of the size and type of units, and on many of the details. Most of the newer developments are used primarily for peaking capacity and consequently they are largely storage propositions. In many cases the development of upriver storage projects on a river containing a number of plants has the added advantage of augmenting the output of the lower plants.

In order to keep capital cost at a minimum which reduces the cost per kilowatt of installed capacity, the trend is toward fewer units of as large a size as possible consistent with the load requirements and the physical limitations of the station. In many cases only a single large unit is installed and provisions are made for the later installation of additional units as the load increases. It is not uncommon for a hydro station to be built in an initial stage under a reduced head with facilities for later increase of capacity by raising the dam or adding gates or flashboards to produce a higher head.

TYPES OF HYDRAULIC UNITS—THE KAPLAN TURBINE

The type of hydraulic turbine used varies with the characteristics of the development and the loading conditions imposed upon the station. Recent improvements in propeller-type runners have greatly expanded the range of heads to which these units are applicable and have made possible the development of low-head sites which were formerly unattractive. Units of this type operate under heads up to 100 ft. Where there is not much variation in head and the unit will operate under fairly constant load, the fixed-blade propeller unit is the most economical, as high efficiency can be maintained and fewer mechanical parts are required. The Kaplan adjustable-blade propeller-type unit has lately received much favorable consideration in this country where high tail water during flood conditions reduces the operating head and variable or unknown loading conditions necessitate curtailed gate openings. With this type of unit high efficiency is maintained by automatically and simultaneously adjusting the angle of the runner blades with the guide vanes to suit any condition of load or head.

The largest size Kaplan turbines are those designed for the Bonneville project which has an initial installation of two 66,000-hp units designed to operate under heads varying from 30 to 69 ft. Two additional 74,000-hp units for this project are under construction. These units are the largest propeller-type units in this country and the highest power Kaplans ever built. The 48,000-kva generators to which they are connected are also the largest in physical dimensions so far constructed. The diameter of the runner, measured from tip to tip of blades, is 280 in., or over 23 ft, and the weight of the rotating element is 1,500,000 lb and the total load on the thrust bearing, including hydraulic thrust, is 3,000,000 lb. Some practical considerations, such as existing shop limitations, the enormous vertical thrust, and high pressure on the bearings of the overhung turbine blades, determined the maximum size of the units. Noteworthy in the fabrication of these units was the employment of welded construction both in shop and field.

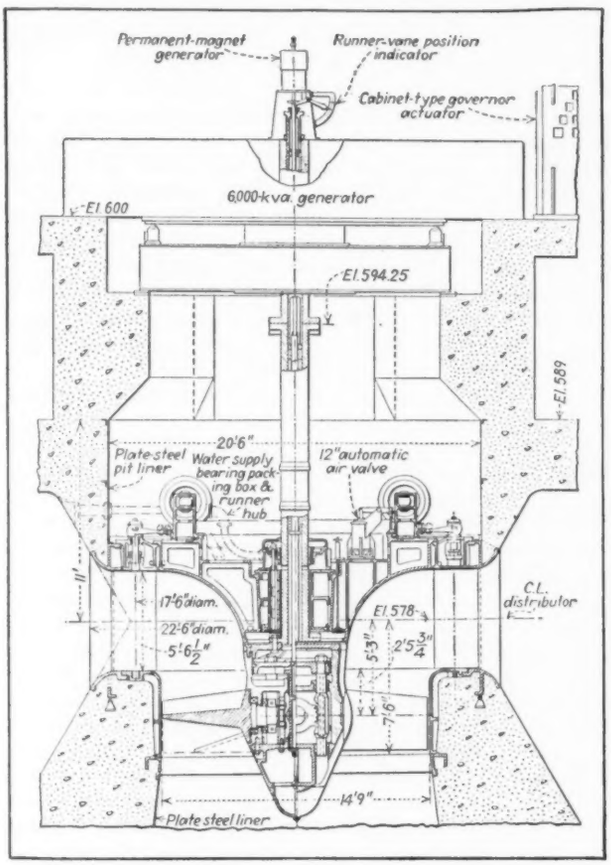
The blades for the Bonneville units are controlled through the governor which actuates by oil pressure a servo-motor piston within the shaft. This piston moves a cross-head in the runner hub which by means of rocker arms attached to each blade adjusts the angle or pitch of the blade. The hollow turbine shaft

is of forged steel 39 in. in diameter and contains three bearings to support the operating rod.

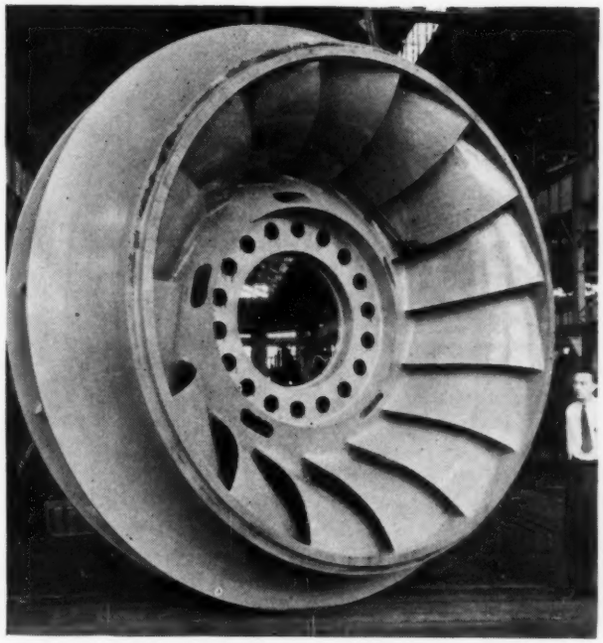
The two units in this plant are controlled by the latest Woodward twin-system, cabinet-type governors which adjust the wicket gates for a change in load and also operate a four-way valve which causes the servo-motor to change the blade angle.

A more recent innovation in adjustable-blade units was adopted for the 7600-hp Marmet turbine of the Kanawha Valley Power Company in West Virginia. This utilizes the principle of the automatic adjustment of the vanes to the most efficient angle by the quantity of water flowing through the wicket gates. With this type of runner the oil-pressure feature of the blade operation is omitted and the blade adjusting gear is placed entirely within the runner shaft and turbine pit, resulting in a considerable saving in governor equipment. The blade axis is placed upstream from its center of pressure so that the water flow through the runner tends to open the blades. The blade pivots are carried on roller bearings in a grease-filled runner hub and interconnected to a balance piston in the upper part of the runner hub. The balance-piston load opposes the moment created by the flow past the runner blades and is provided with low-pressure water supply which acts in one direction only and tends to close the blades which are free to assume a condition of balance between the two opposing moments.

Two other units of this design are also in operation, one at the Winfield plant and one at the London plant of the Kanawha Valley Power Company, both near Charleston, W. Va. Two similar units rated 10,000 hp at 61 ft head are under construction for the Austin Dam plant in Texas.



CROSS SECTION OF 7600-HP AUTOMATICALLY ADJUSTABLE-BLADE TURBINE RUNNER FOR MARMET PLANT, KANAWHA VALLEY POWER CO.



SHOP VIEW OF FRANCIS-TYPE REACTION RUNNER FOR 115,000-HP BOULDER DAM UNIT

Tests made with model runners in the manufacturer's hydraulic laboratories were used on both of the aforementioned types of units to determine the shape of blades and proper pitch angle under variable conditions of load and head. Because of high specific speeds and water velocities, cavitation becomes an important factor, and cavitation tests are run under all conditions of loads and heads to determine the areas most subjected to this action. In some of the propeller units under construction, prewelding of these areas with a layer of stainless steel has been the practice.

THE FRANCIS RUNNER

For medium low heads and medium high heads up to about 1000 ft, the well-established Francis reaction runner seems to predominate. In general, improvements in this field have been mainly in size of installation, simplification, and greater reliability of operation. Outstanding in this field are the vertical-shaft 115,000-hp Boulder Dam units under a rated head of 480 ft, the most powerful units in the world now in operation but these are soon to be exceeded by the Grand Coulee units now under construction and rated at 150,000 hp to operate under a head of 330 ft. Here again the size has been limited only by practical mechanical considerations. The major problems involved in these large units are those of construction and sectionalizing for transportation, and the methods of assembling in the field, especially where large metal spiral casings are involved. In connection with the Boulder turbines the problem was readily met in that casings are made up of cast-steel sections with bolted flanged joints. Where plate-steel design is involved, the question of field riveting or of welding requires careful consideration. Riveting heavy plates locally is a cumbersome job and field welding again involves the problem of stress relief.

The development of the Kingsbury type of thrust bearing has been an important contribution to the development of large-size reaction wheels. A modification of this, the spherical Kingsbury bearing which is a combined thrust and guide bearing, offers advantages where it is desirable to reduce to a

minimum the clearances between the stationary and rotating parts of the generator and turbine. This type of bearing has been in operation since 1930 at the Rosetilla development in Mexico, built for the Cia Agricola y de Fuerza Electrica del Rio Conchos, S. A.

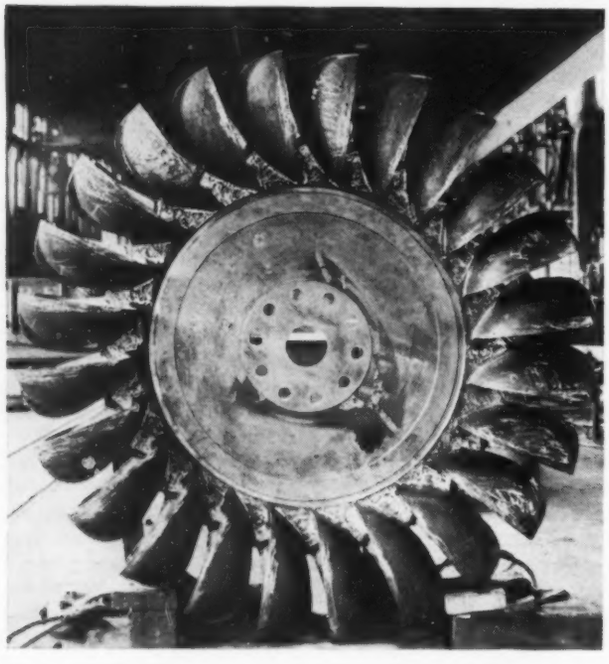
THE VERTICAL OVERHUNG TYPE OF GENERATOR

Another innovation in design is the umbrella or overhung type of generator which makes possible a two-bearing unit with the reduction of head clearances and consequent superstructure. It is particularly adaptable for the outdoor type of generating station. This utilizes an overhead gantry crane to assemble or dismantle the units and thereby eliminates expensive superstructure as well as substructure and column supports necessary to take the weight of the machinery parts. This type of plant was pioneered by Electric Bond and Share Company engineers and at present more than twenty plants in this country have adopted the outdoor feature.

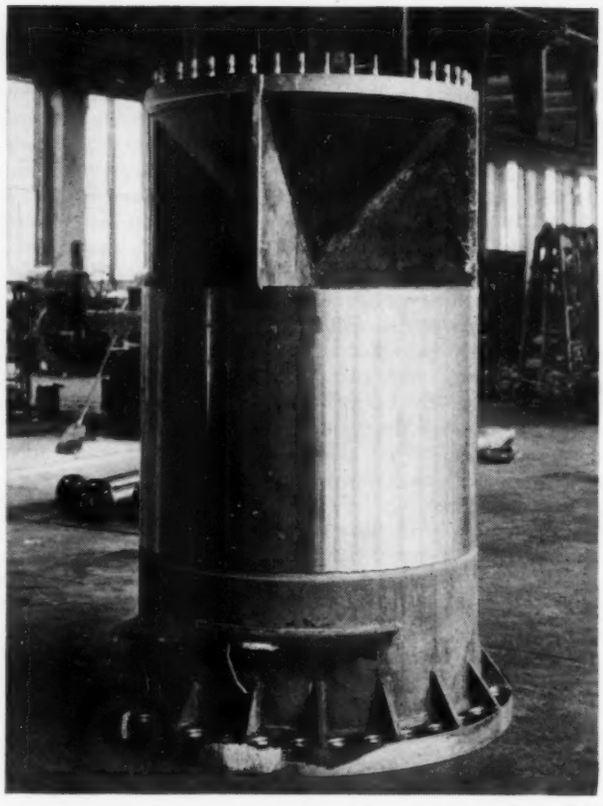
A typical installation is the Morony development built in Montana. There are two 31,000-hp units in this plant operating under a head of 80 ft. The hydraulic features of this plant are worthy of particular attention because of their simplicity and efficiency. The design of the intake was based on extensive model tests to determine the most economically efficient shape of bellmouth. The penstock is straight from intake gates to the casing, thus reducing to a minimum the friction losses. The turbine efficiency, as evidenced from Gibson tests, was 93 per cent and the over-all hydraulic efficiency from head water to tail water was 92.6 per cent.

HIGH-HEAD INSTALLATIONS—FRANCIS AND IMPULSE WHEELS

The Ariel plant of the Inland Power & Light Company on the Lewis River in Washington is another example of a medium-high-head installation embodying the outdoor type of construction. This plant now has one 63,000-hp unit in operation under a head of 187 ft with provisions for the future installation of three additional units. A novel feature in the construction of this plant was the bridging of a deep ravine



SHOP VIEW OF SOLID CAST IMPULSE WHEEL FOR 6000-HP UNIT TO OPERATE UNDER 1700-FT HEAD IN PUERTO RICO



42-IN. HOWELL BUNGER VALVE FOR METROPOLITAN WATER DISTRICT IN SOUTHERN CALIFORNIA

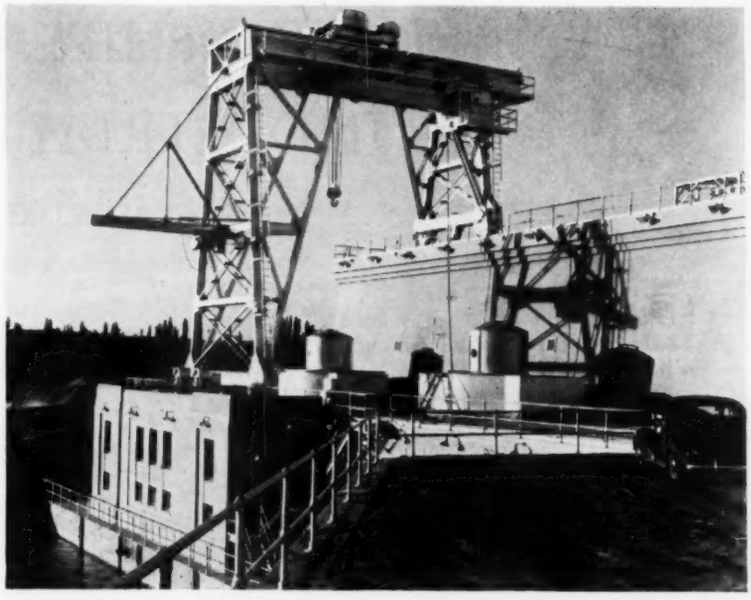
across the river channel by a reinforced-concrete arch upon which the powerhouse substructure was placed. This resulted in the saving of considerable substructure concrete and excavation. The Kerr plant recently completed for The Montana Power Company utilizes the 1,100,000 acre-feet of water in Flathead Lake to operate a 77,000-hp unit under a head of 170 ft. The powerhouse for this plant was placed on a shelf blasted out of a canyon wall which at this point is 400 ft high. The possibility of frost-loosened rock made the outdoor type of station impracticable and instead a specially designed "bombproof" roof was utilized.

A typical installation of a high-head Francis reaction turbine is the Waterville development of the Carolina Power & Light Company in North Carolina. This comprised three units of 49,000 hp each operating under a gross head of 850 ft which is reduced by friction in a six-mile tunnel bored through the Great Smoky Mountains to a net operating head of 755 ft.

At these higher heads there is an arbitrary choice between the reaction wheels and the impulse type. The former type, however, can attain higher efficiencies and can usually be justified economically for heads under 1000 ft. Above this limit impulse wheels are used almost exclusively, as speeds become higher, cavitation limits are critical, and the stresses in the head cover and casings of reaction wheels would be excessive. Impulse wheels have been installed in this country up to 3000-ft heads and are usually of the horizontal type. They may be built either with a single or double runner and with one to four jets. Research and improvements in bucket and nozzle design have greatly improved the efficiencies attainable with impulse wheels. A novel feature leading to further economy is the casting integrally of disks and runners. This permits the use of a greater number of buckets more closely

spaced, which in turn enable high speeds and efficiency. Welded construction has also aided greatly in both shop fabrication and field construction. The largest impulse units built in this country, both in power and physical dimensions, are the 70,000-hp wheels in service at the Big Creek No. 2-A development of the Southern California Edison Company. These units are of the two-runner, single-nozzle type, and operate under a head of 2200 ft at a speed of 250 rpm. The pitch diameter of the runner is $13\frac{1}{2}$ ft.

Recent designs of new units of the impulse type indicate the preference of the sleeve-type stream deflector mounted in front of the orifice of the jet and diverting the water from the buckets, rather than the old-type deflecting nozzle, which required movement of the entire nozzle pipe in its hinged joint or the governor-controlled needle with auxiliary relief nozzle for by-passing the flow. Relief valves directly responsive to pressure rises are no longer being employed in modern installations.



OUTDOOR GENERATOR, UPPER SALMON DEVELOPMENT, IDAHO POWER CO.

VALVE AND GATE DESIGN

Outstanding developments in valve and gate design have resulted from the high pressures and sizes of penstocks made necessary by the high-capacity turbine units. The rotary valve has recently been introduced in this country and offer distinct advantages in hydraulic efficiency. Another definite contribution to the field of balanced free-discharge valves is the Howell-Bunger valve in which the jet issues from an annular opening in front of a horizontally moving cone.

In the field of crest gates for dams, a new design of roller gates has been perfected which promises greatly to improve their performance and reduce their cost. This results from placing the drum at the bottom with the apron on top, which arrangement is opposite to that used in former designs. The bottom drum and top-mounted apron are much lighter in weight than the old-style drum and apron and save at least 30 per cent in the cost of gate and piers. The lower costs resulting from these improvements place the new design of roller gates in a competitive position with the taintor and various types of slide gates.

SIMPLIFICATION AND ECONOMY OF DESIGN ESSENTIAL

There have been many other outstanding developments in the hydroelectric field brought about chiefly by the special problems of design, transportation, and fabrication of equipment of unprecedented size. These achievements stand as a tribute to the ingenuity and technical skill of the turbine manufacturers. There has also been a constant incentive toward simplification and economy of design in order to reduce operating and maintenance costs, in which the manufacturer has also been called to play his part.

It is obvious from recent developments that there are at present two distinct schools of thought in the development of hydroelectric power: One has been promulgated by the magnitude of government-financed projects calling for the installation of power facilities in conjunction with other non-related purposes such as flood control, irrigation, and navigation; the other is that evolved through years of experience by private companies in which the development of power is based upon sound economic practice.

In the former theory, only a hypothetical portion of the construction cost is charged against power. There is not, therefore, the incentive toward the economical design of units to justify the proportion of the costs which are usually unknown until after the project is completed. Units of large size are installed in anticipation of load in undeveloped regions, and requirements of operation are matters of conjecture.

In the development of hydro power by private initiative, all elements of cost must be taken into consideration and economic studies made to justify selection as against obtaining the required amount of energy by other methods, such as by thermal plants or the purchase of surplus power from neighboring systems. Careful analysis must be made of system requirements to insure the selection of the size and type of installation best adapted to the load curves already established. Because of the high capital investment required for hydro plants as compared to steam plants, it is difficult to justify a hydroelectric development except under very favorable circumstances. In order to make it economically feasible, it is essential to reduce the investment cost and consequent fixed charges by utilizing the utmost simplicity in design. This necessitates elimination of all nonutilitarian features and excess capacity. It precludes installation of a large number of units of high capacity the output of which cannot readily be absorbed by the normal load growth within a reasonable time.

This simplicity and adaptability to system requirements is exemplified by smaller flexible developments such as the Twin Falls plant of the Idaho Power Co. on the Snake River in Idaho, where a single unit has been installed with a low concrete arch dam and provision is made for raising the height of the dam when required and utilizing the machinery under the higher head. This plant is also capable of automatic operation by remote control from a neighboring plant. Downstream from this plant is the recently completed Upper Salmon development of the Idaho Power Company where simplicity has been the keynote, and a single overhead crane handles head gates, turbine and generator equipment, draft-tube-gates and transformers. Space requirements in this plant have been kept at an absolute minimum, and maximum yearly energy has been obtained by the high efficiency of fixed-blade propeller-type units.

The author wishes to acknowledge the very material help of the various turbine manufacturers in supplying data for this discussion and also to pay tribute to M. G. Salzman, of Ebasco Services Incorporated, for his assistance in its preparation.

SOCIAL RELATIONSHIPS *and* INDUSTRIAL UNREST

By DOUGLAS McGREGOR

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

ALTHOUGH this book[1] was published three years ago, it has not received the attention it warrants. Possibly the reason lies in the title. The subtitle, "A Study in Human Relations Based on an Analysis of Present-Day Industrial Civilization," is much more informative. Professor Whitehead, himself an engineer, has presented in this volume a thought-provoking analysis of some of the major factors underlying the current unrest in industry.

A book by the same author,[2] presenting a detailed analysis of the data gathered in the relay test room at the Hawthorne plant of the Western Electric Company, has been widely discussed during the last few months. The present volume—although actually published earlier—is a logical sequel to "The Industrial Worker." It deals with broader implications of those data, and also with data obtained through subsequent study of other groups of workers in the same plant.

The thesis of the author is relatively simply outlined, although it is perhaps less convincing when stated apart from the evidence upon which it is based. Modern industry is oriented around the principle of continuous change in the organization of men and machines for the more efficient achievement of the economic purposes of industry (more profits, higher wages, a higher standard of living, and the like). Change is planned and instigated by management on the basis of considerations which are primarily technological. For a number of reasons, which we will consider in a moment, workers possess a vague and apparently irrational fear of these changes. In defense they develop elaborate means for resisting them. Friction, misunderstanding, resentment, and mutual recrimination are all too frequently the outcome of these circumstances. The solution, Whitehead believes, lies in a more realistic appreciation of a psychological problem, namely, what constitutes effective leadership on the part of modern industrial management? Hence the title of this book.

WORKER ANTAGONISM TOWARD MANAGEMENT PROPOSALS BASED ON FEAR

There will be few objections to the statement that the major function of industrial management today is the promotion of ever greater economic efficiency. Nor will it be denied that frequent changes in the techniques of production, in the organization of personnel, and in work routines, accompany the pursuit of this goal. But it may not be so obvious that workers often fear and resent these changes. The author argues that restriction of output, antagonism toward many perfectly logical proposals of management, the failure of effective communication up the line from worker to management, and the like, are all evidence of fear and resentment of change. And this in the face of the seemingly obvious fact that such change is often advantageous to the worker as well as to management.

Data gathered from the Relay Test Group, from a slightly larger group of male employees called the Bank Wiring Group, and from interviews with over 20,000 Western Electric employees provide evidence for the author's contentions. They also provide some clues concerning the reasons for the existence of these apparently illogical attitudes among workers. The author fits these clues neatly into the conceptual framework of modern sociology and social psychology, and thus gives the reader an integrated picture.

DEVELOPMENT OF MINIATURE SOCIETIES IN WORKER GROUPS

Whenever groups of individuals come into constant face-to-face relationships, they tend to develop a relatively stable set of social norms—accepted habits of action and belief. A leader typically emerges to coordinate the group, and to serve as the guardian and defender of the developing norms. In short, any relatively permanent face-to-face group tends to become a miniature society within the larger social framework—a society with a number of rituals and attitudes, and a structure of social relationships which are its own unique characteristics. Whitehead's data provide evidence for his assertion that the modern factory is a collection of such small subsocieties. It is the stability of the routines and of the social relationships within these societies that is continually threatened by management's attempt to build an ever more efficient organization. And it is in an almost blind attempt to protect this stability that many apparently illogical practices arise among worker groups. They are illogical when one considers only the industrial aim of economic efficiency. They are quite logical when one takes into account also the immediate satisfactions that arise from face-to-face social interaction.

In the face of threats—fancied or real—to personal security, people are quick to relinquish their long-range goals in the interest of protecting their more immediate satisfactions. This is a reasonably sound psychological generalization. To apply it to the industrial worker indicates a recognition of the fact that economic motives operate, not in a vacuum but in a social world. Many writers give lip service to this fact; few recognize its implications. For example, deliberate restriction of output by the worker can mean but one thing: Something else is more important to him than the income he loses through that restriction. Whitehead offers a realistic picture of the nature of this something, and an analysis of its causes and effects.

It is not possible within the scope of this review to discuss in detail the author's suggestions of practical ways for dealing with this situation through more intelligent and more realistic industrial leadership. He is careful to insist that his suggestions are primarily stimuli to further thought on the part of the reader. They serve this function admirably.

(*Continued on page 604*)

[1] "Leadership in a Free Society," by T. N. Whitehead, Cambridge, Mass., Harvard University Press, 1936.

[2] "The Industrial Worker," by T. N. Whitehead, Cambridge, Mass., Harvard University Press, 1938. Reviewed in MECHANICAL ENGINEERING by E. R. Livernash, December, 1938, p. 954.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

POWER *and* FUEL

A Résumé of Present-Day Trends

By E. G. BAILEY[1]

WHILE SUCH FUELS as coal, oil, and gas are most commonly used in the generation of power and process steam, there is an increase in the use of wood refuse, bark, waste liquor from pulp mills, tar, and miscellaneous fuels. These are being burned more extensively and more efficiently. For the best use of some of them, special water-cooled-furnace designs have been developed.

Some new electrical generating stations are being built at locations where gas and a variety of low-grade fuels are available from oil refineries, blast furnaces, etc. Other stations have arranged to take dump gas from pipe lines where major investments have been made to transport gas to centers having a variable demand.

While fuel oil is a more uniform commodity than coal, it is subject to change in quality and other properties due to improvements and changes in the cracking processes. The ash content is still relatively low but, at times, serious slag difficulties are encountered.

The trend in the mining and preparation of coal is toward mechanization of the mines, which results in adding more dirt and impurities to the coal as it comes to the tipple. This naturally requires washing or cleaning and, in many regions, more sizing. While a part of this development is for the benefit of the domestic or small steam user, it affects the steam coal supply, sometimes favorably and sometimes in the direction of added costs.

The bituminous industry is at present organizing a research program of greater scope than ever before, and well it may, for there is much yet to be learned regarding the properties of coal and especially of the ash and its effect upon capacity, efficiency, and other costs of operation. The power-generating companies and the manufacturers of fuel-preparation and burning equipment should cooperate wholeheartedly with the coal industry in every way possible in this research to make it effective and useful to all concerned.

FUEL BURNING

There is continued activity along the line of stoker development, but it is largely concentrated on house stokers and the smaller steam units. In larger units pulverized coal is being further extended because of the proved economy of this method of firing. Also there is the advantage of quickly changing from coal to oil and gas, and vice versa. The advantage of multifuel supply is being more and more appreciated, for no sooner do we face a possibility of being forced from oil to coal, when as now we are facing an actual coal shortage, than we realize how fortunate are those who can quickly change to oil or to some other fuel.

Improvements continue in burners, furnaces, and pulverizers. The bin system is largely giving way to the unit or direct-fired systems. Water-cooled furnaces predominate, even in the smaller boiler units. Dry-ash removal is used for the smaller units and for the larger furnaces where relatively high-fusing ash is available. Slag-tap furnaces continue in favor for a large number of installations with continuous tapping predominating at the present time.

The arrangement of furnace walls and burners is receiving more attention with respect to proper ignition of fuel, length of gas travel, mixing of fuel and air, proper rates of heat absorption, and recovering the maximum percentage of ash within the furnace, thereby minimizing the difficulties from slag, choking of gas passages, and fan erosion. More attention is being given to capacities along the line of Btu per square foot of radiant heat-receiving surface and less to Btu per cubic foot of furnace volume. Deslaggers and wall-cleaning equipment of the retractable type for the hotter zones are being developed and improved on an extensive scale.

Smoke, as such, is not a serious problem in the larger plants, except occasionally due largely to laxity in operation. In smaller plants, the prevention of smoke needs further attention. Equipment for the removal of fly ash has been installed in a large number of units. Both the electrical precipitators and the mechanical-cyclone types have been used with generally satisfactory results. The trend is toward collecting the coarser particles in the furnace and, at the same time, designing the collectors with more liberality for a higher percentage of recovery.

STEAM GENERATION

Boilers of 300,000 to 700,000 lb of steam per hr are more popular in central-station design, with a smaller number up to 900,000 to 1,000,000 lb per hr, and a goodly number below 300,000. Most of the latter are for pressures and temperatures of 900 lb per sq in. or less, while the larger units are mostly for 1400 lb pressure and 900 to 950 F steam temperature, and a few up to 2200 and 2500 lb pressure.

The trend in boiler design may seem to many to be divergent from that of the past. Only a short generation ago, the boiler was pretty well standardized with three or four types. Then came demands for change. Departures from past designs have been made by steps and incremental stages without radical departure in principles.

These demanded changes were to accommodate larger and more efficient stokers, pulverized coal, multiple fuels, water-cooled furnaces, higher steam pressures, higher steam temperatures, superheat control, economizers, air preheaters, greater steam-output capacities, clean steam, long periods of operation at high load factors, and maximum efficiency.

Considerable success has already been attained toward meeting these demands. The time is rapidly approaching when a basic analysis of these experiences and the present requirements will result in standardization of types which will likely remain for a longer time, because now we are more nearly within the range of economic limits of pressure, temperature, capacity, and efficiency. Fuel from any source will be looked upon for its Btu value, with minor variations in equipment or rates of combustion to allow for its peculiarities, which will revolve largely about impurities such as moisture and ash accompanying the particular carbon or carbon-hydrogen composition.

Boilers for capacities up to 200,000 lb of steam per hr and steam at pressures up to 900 lb per sq in. and temperatures up to 850 F are likely to remain along the design lines of several now available, having a cubical furnace, suitable for burning oil, gas, or pulverized coal with dry-ash removal. Such boilers have an upper and a lower drum with water-cooled-furnace walls and boiler-tube bank, all integral as to circulation with a minimum of headers, baffles, and brickwork.

Boilers for high pressure and larger capacities will settle the argument between straight-tube and bent-tube banks by omitting both to a very large extent, and will consist largely of

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[1] Vice-President, The Babcock & Wilcox Company, New York, N. Y., and President, Bailey Meter Co., Cleveland, Ohio.

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furnace walls with one or two drums, superheater, economizer, and air heater. The furnace, as previously stated, will be designed largely with respect to the problem of burning the fuel efficiently and handling the resulting ash effectively, with sufficient radiant-heat-absorbing surface to cool the gases to the proper temperature for entrance into the superheater.

Forced-circulation boilers are being operated in sufficient numbers in this country to establish what may be their field for economic use, which for the present seems to be limited to the smaller sizes where weight and height limitations are unfavorable to the natural circulation system. However, improvements in natural circulation are actively being accomplished through greater knowledge of critical velocities, rates of heat absorption, and better separation of steam from the water in the boiler circulating system.

The cleaning of steam has made phenomenal strides. Really clean steam is now readily attainable. Water treatment is progressing satisfactorily.

The control of superheat is a partially solved problem. Recently the gas-by-pass method has predominated, but further study should be given to the attemperator, or partial desuperheating between superheater sections. Either method is available, but the economics and relative desirability can be determined only through use and comparison of the results from both systems.

Experience with steam temperatures above 875 F has been of relatively short duration. The selection of alloys has been based largely upon the available data with respect to creep; these data are very voluminous. Experiences in the oil-refining field have to a certain extent blazed the path for steam so that considerable assurance is felt in the selection of alloys for steam temperatures up to 950 F.

There is not as much knowledge or precedent with respect to oxidation resulting from the decomposition of steam. Dean Potter at Purdue and others are working actively in this field.

Experience to date has shown that the factors of safety with respect to both creep and oxidation are approximately equal. Neither is so great but that considerable care should be exercised in the operation of boiler units to see that gases entering superheaters should be within the limits for which they are designed with respect to both temperature and velocity. Stratification due to unbalanced firing, unequal accumulation of slag or sponge-ash, nonuniform cleaning, or any other cause should be carefully avoided. The manufacturer of superheaters has attempted to lean toward smaller factors of safety in the selection of alloys rather than furnish equipment of unduly high initial cost. It is therefore in the hands of the operator to prolong its life by careful operation.

STEAM-TURBINE GENERATORS

Trends in larger turbine-generator designs in recent years have been in the direction of higher initial pressures and temperatures, larger capacities at 3600 rpm, hydrogen cooling of generators, and greater use of superposed turbines.

Initial pressures of 1200 lb per sq in. are being used most frequently with 800 lb a close second. The highest initial pressure for which a turbine is being built is 2300 lb.

An initial temperature of 900 to 950 F is the most popular with 650 to 750 F and 800 to 850 F the next in order of importance. In capacities up to 50,000 and 60,000 kw, 3600 rpm is replacing 1800 rpm and 1200 rpm has disappeared. Since the first hydrogen-cooled generator was placed in service in October, 1937, this form of generator cooling has been widely accepted and recently more than 90 per cent of all large generators sold are of this type. A number of superposed turbines have been placed in operation within the last 2 years. Recently, several more large superposed turbines have been sold, indicating that this method of obtaining additional power and improved economy is justifying expectations.

All these improvements in operating conditions have reduced turbine-water-rate guarantees materially; a number of recent station tests indicate that these guarantees are being met.

The outstanding problem in this development was that relating to the increase of steam temperature, principally the phenomenon of creep. The first approach to this problem was to determine as completely as possible the high-temperature behavior, under stress, of materials then in common use and to follow this with a search for improved materials. This creep program is supplemented with many other studies on the same materials, such as aging, impact, fatigue, relaxation, expansion, and some short-time tests.

Central-station turbines incorporate more or less standardized mechanical details, the principal features of which are:

(*a*) All blading is of the shrouded type and the required clearances are maintained by thin sealing strips. Lashing wires are eliminated except for the last rows of certain condensing machines. All condensing machines are equipped with moisture catchers in the last stages, which have proved effective in removing moisture and thus reducing the blade erosion. In all condensing machines, the blades in the last rotating rows are shielded with stellite strips to protect them against erosion.

(*b*) Solid rotors are used, except in certain condensing machines where the last rows of blades are carried on disks shrunk on the shaft.

(*c*) Multivalve, integral steam chests are mounted on top of the high-pressure cylinders. Valves are operated by hydraulic governors mounted on the front pedestals.

(*d*) Inverted throttle valves are mounted either directly on the high-pressure cylinders or below the floor level, depending upon the size of the unit and plant arrangements.

(*e*) Rigid couplings are used in the rotating system.

PRESENT-DAY TREND IN POWER-STATION AUXILIARIES

Several years ago there began a definite trend toward motor-driven auxiliaries in power plants. With the exception of a few installations involving topping units for existing machines, which do not have extraction openings and where the heat balance justifies auxiliary turbines for extraction purposes, the present practice seems to confirm this trend, and motor-driven auxiliaries continue to predominate.

In later years reliability and simplicity have been emphasized more and more. In many cases, constant-speed motors with associated supplementary control have been used instead of variable-speed motors, resulting in much simpler control and only a slight loss in efficiency for the individual drive. This procedure has been entirely acceptable where the plants under consideration are relatively few but, as their number increases and the load factors go down, more flexible control will undoubtedly be found advantageous.

The advent of higher steam pressures has resulted in 3600-rpm boiler-feed pumps. Two common methods of drive are variable speed for the entire unit or constant-speed drive for the high-pressure section with variable-speed drive for the booster section.

TURBINES FOR AUXILIARIES—INDUSTRIAL TURBINES

Turbines which have hitherto been considered as industrial-type machines are finding applications in the central-station industry in the form of auxiliary drives, particularly as boiler-feed-pump drives in connection with superposed-turbine installations. When old plants are rehabilitated by superposition there is frequently a problem of obtaining adequate means for feedwater heating.

(*Continued on page 588*)

BRAKING HIGH-SPEED TRAINS *as an* ENGINEERING PROBLEM

Part I—Principles of Modern Brake-System Development

By JOSEPH C. McCUNE

DIRECTOR OF RESEARCH, WESTINGHOUSE AIR BRAKE COMPANY, WILMERDING, PA.

AIR-BRAKE PRACTICE which, by converting mechanical (kinetic) energy into heat, reverses the customary engineering process, as in prime movers, of converting heat into mechanical energy, is but little understood by engineers and is only occasionally referred to in engineering literature. Because of the magnitude of the engineering problems involved where, for example, a modern brake system may be required to dissipate, as an instantaneous maximum, 2000 hp per axle, the subject of high-speed braking should be of general interest.

In the air-brake art, Newton's laws apply directly and to a degree seldom found in other branches of engineering. Moreover the principles of analytical mechanics are particularly applicable and in fact essential to an understanding of the force relationships existing during a stop.

In another respect, there is a great distinction between the problems faced in the air-brake art and those current in other fields; i.e., air-brake practice is mostly concerned with transient phenomena and conditions influenced by variables, many of which are beyond control. Ordinarily the engineer must consider questions of equilibrium, of steady flow, or of output only occasionally subject to overloads.

In all fields transient phenomena are difficult to understand, a condition which prevails particularly in the air-brake art where they cannot be studied in detail without involving the operation of trains on actual track. Because of the great expense and labor entailed, such opportunities for study are few and infrequent. Further, it is difficult to devise test apparatus which adequately and reliably will give the information desired. Consequently the air-brake engineer to a greater degree than engineers in general must rely upon inferences and conclusions reached over a long period of time to supplement the paucity of reliable test data. In other words, the practical phases of the air-brake art rest upon an empirical foundation.

This is true not only in American and Canadian practice, but also in that prevailing in Europe, especially in connection with high-speed braking in France, Germany, and Italy. It will be apparent hereafter that air-brake engineers in Europe approached the problems of high-speed braking from much the same viewpoint as that found in the United States and Canada.

ELEMENTS OF THE BRAKING PROBLEM

By Newton's first law, a body, acted upon by no forces or by balanced forces remains in a state of rest or of uniform motion in a straight line. Thus a train continues in motion until a retarding force is caused to act upon it, since the forces acting upon a train in motion, due to friction and wind resistance, are of minor consequence from a practical braking standpoint. By Newton's second law, the retardation produced by this force is directly proportional to the force and inversely proportional to the mass. Stated in more familiar terms; the retarding force is equal to the mass times the retardation, both in suitable units.

This elementary relationship is of frequent use in braking problems because it ties together several important factors. Thus, if the retarding force is equal to the weight being retarded, the retardation obtained is g or 32.2 ft per sec^2, or with sufficient exactness for practical purposes, 22 mphps. If the retarding force is 20 per cent of the weight being braked, the retardation is 4.4 mphps. Conversely, if the retardation observed is 4.4 mphps, then it is known that the retarding force must be 400 lb per ton. Since 4.4 mphps is not an impossible retardation, it is evident that emergency-stop distances are not so much influenced as generally supposed by grades, bearing friction, and wind resistance. As an illustration; to balance the accelerating force due to gravity on a 1 per cent grade requires a force of 20 lb per ton, which is only 5 per cent of the 400 lb per ton required to produce a retardation of 4.4 mphps.

Newton's second law defines the retarding force required to produce a desired rate of retardation. However, by the laws of analytical mechanics, this force cannot be internal but must, on the contrary, be external to the train. The only manner in which external forces can be brought to bear upon the train is through the medium of the rail or the surrounding atmosphere. As wind resistance on the train is negligible from the braking viewpoint, the force which stops the train is the retarding force set up by the rail.

RETARDING FORCES

The retarding force at the rail is called into being by applying brakes to the wheels, so that their resistance to rotation is tremendously increased. A force to cause continued rotation of the wheels is thus set up at the rail. It is forces of this kind which eventually stop the train.

It is important to observe that the braking action takes place because of the retarding force set up at each wheel. The retardation observed on the train is due to the summation of all such forces; i.e., if a train of 1000 tons is noted to have a retardation of 2.2 mphps, it is evident that the train as a whole is subject to a retarding force of 100 tons. But clearly this is not a single force of 100 tons, but instead is a resultant force or the sum of the retarding forces acting at each wheel. This situation is one of the most difficult encountered in installing powerful high-speed brakes. It can be appreciated better by considering the subject of rail adhesion.

RAIL ADHESION

It has been said that, when brakes are applied to car wheels, a retarding force, in so far as the train is concerned, is set up at the rail in order to preserve rotation of the

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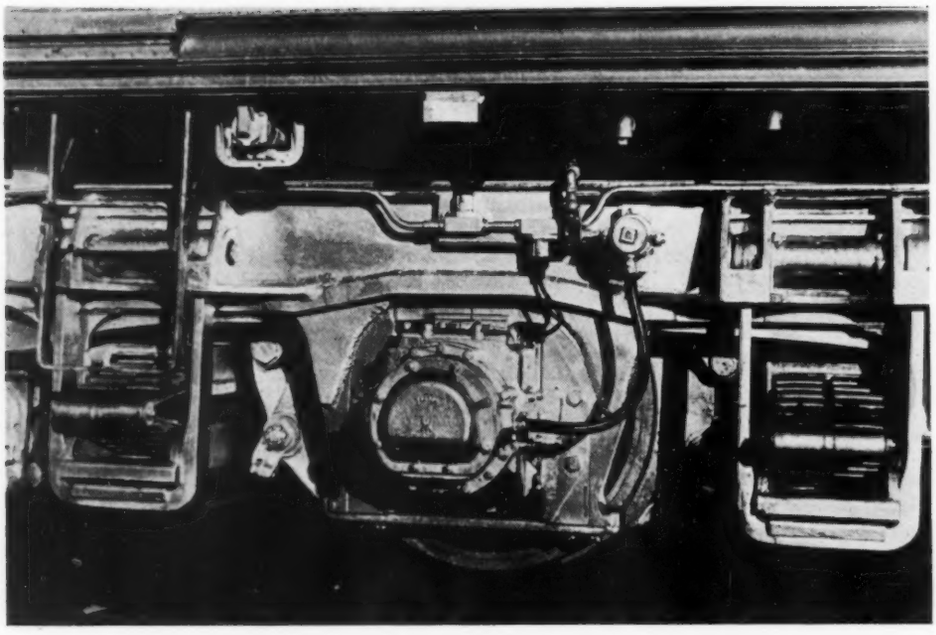

FIG. 1 DECELOSTAT INSTALLED AT END OF AXLE

wheels. Obviously, this retarding force cannot be increased to an indefinite extent but instead has a definite limit. This limit is fixed by the coefficient of adhesion which is defined as the ratio of the braking friction (retarding force) acting upon the wheel to the load carried by the wheel when slipping impends. The wheel is said to slip when its rotative speed is such that its peripheral velocity is less than the car velocity; it slides when its rotative speed is zero; and it is said to roll freely when its peripheral velocity equals the car velocity.

Clearly, the maximum retarding force at the rail is secured when the wheel rolls freely, because then the friction between wheel and rail is static or a maximum; whereas, when the wheel slips or slides, the friction between rail and wheel is kinetic and is correspondingly reduced. To obtain relatively short emergency stops from high speeds, therefore, it is necessary that all wheels continue to roll freely when the brakes are applied. On the other hand, all wheels should be subject to braking friction just short of that sufficient to cause slipping, in order that the minimum stop distance may be realized. From what has been said previously, it is apparent that the braking friction must be adjusted to the load carried by each wheel. If each wheel had an identical load, it would be relatively easy to make such an adjustment. But in modern high-speed trains, there is a wide disparity in wheel loads. It is necessary, therefore, to predetermine the braking friction for each wheel load, which, because of reasons given hereafter, is a matter of great difficulty. The net result is that, although the train may make a comparatively long stop and thus indicate retarding forces well below the slipping value, a pair of wheels on a single axle may slide because the axle is "overbraked." The difficulty of obtaining uniform braking on all axles in a train is one of the principal obstacles to obtaining short stops from high speeds.

From all of the foregoing, it will be apparent that the ultimate limit encountered in the effort to provide short stops is rail adhesion. Rail adhesion was first investigated by Galton in England many years ago and his tests are referred to in practically all handbooks. In the late twenties, an investigation was conducted in Germany where high-speed braking was then being inaugurated. On the basis of the results of this investigation, Metzken arrived at the conclusion that the brake friction should not exceed 15 per cent of the weight being braked, which would limit the maximum retardation to a value of 3.3 mphps. This German investigation disclosed coefficients of adhesion on dry tracks of from 18 to 26 per cent; on track under unfavorable climatic conditions, i.e., drizzling rain, fog, snow, frost, of values as low as 8 per cent. It was also found —confirming the Galton tests—that sand improved the adhesion and gave values of 30 per cent, apparently, from the account, under unfavorable climatic conditions.

Less elaborate investigations than those just mentioned have been carried out in the United States from time to time. These investigations have disclosed coefficients as low as about 10 per cent under the most unfavorable conditions and as high as about 40 per cent under the most favorable conditions and with the rail sanded. It will be noted that 40 per cent as the maximum value for rail adhesion is markedly less than the 100 per cent sometimes found as highway adhesion. Research in the United States has been mainly directed to ascertaining if the adhesion at high speeds is substantially as great as at low speeds. All tests have indicated that this is the case. A striking illustration is that a retardation of 5.3 mphps, despite weight transfer, etc., was actually obtained on a single test car at a speed of 100 mph on a sanded rail and at the beginning of a light rain.

An extended discussion of coefficients of adhesion is somewhat academic in that a knowledge of such coefficients is of little practical help in solving the dilemma the application of the modern powerful brake presents. Automobile brakes are instantly responsive to the wishes of the operator who is fully aware of the braking action. With train brakes, on the other hand, in an emergency application, the brakes cannot be released by the engineman with the train in motion. In any event, although he is aware of the retardation produced on the train as a whole by action of the brakes, he is not cognizant of what is occurring at the individual axles. On this account the avoidance of slid-flat wheels in train braking is a matter of considerable difficulty.

If a powerful brake is installed, then an emergency application, on a poor rail, will cause many wheels to slide and thereby increase the stop distance. If a powerful brake is not applied, then stops from high speeds become unacceptably long. The first practical step toward a solution is to provide sanding facilities, as is now done with high-speed trains in segregated service, so that in emergency applications sand may make a poor rail the equivalent of a good rail. However, sanding alone is not sufficient, because the brake friction may be abnormally high at the moment or the load on the wheel may be reduced by vertical oscillations, etc. Therefore, in order to cause appropriate braking action to meet conditions as they exist at a particular time, as a second step, it is necessary to provide a device known as a "Decelostat" which is responsive

to deceleration or retardation.

PRINCIPLE OF THE DECELOSTAT

In principle, the action of this device is simple. Its operation is based upon the fact that the retardation rate experienced by the wheels during the slipping period, before actual sliding commences, is materially in excess of the retardation due to any normal braking action. That this is so can be appreciated readily when it is considered that, with the wheels rolling freely at car speed, the braking friction is directed almost entirely toward retarding the translatory motion of the wheel load and but little is devoted to retarding the rotary motion of the wheels and axle. On the other hand, when the wheels and axle slip, a very substantial portion of the braking friction acts to retard their rotation. Consequently, the angular retardation of the wheels and axle during the slipping period is greatly beyond that occurring when the maximum retardation is obtained with the train itself. It follows that, if the angular retardation of the wheel exceeds the predetermined braking maximum, it can safely be taken as a signal that the wheels are slipping and that the braking friction should be reduced. This is accomplished by a partial or temporary release of the brakes.

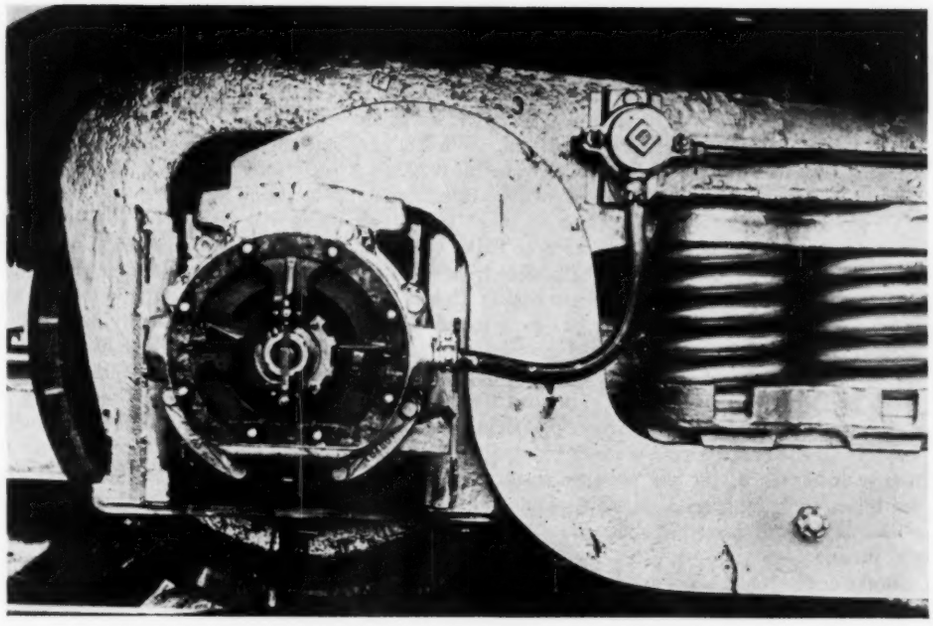

FIG. 2 VIEW OF DECELOSTAT WITH COVER REMOVED

A Decelostat unit is located at one end of each axle. Considering the mode of operation rather than the structure, its principal element is a small flywheel mounted, in effect, upon the axle and free to rotate thereon. It is connected to the axle with a leaf spring. If the wheel rotates with uniform speed, the leaf spring causes the free flywheel to rotate at the same speed and there is no relative movement between the two. However, if the axle is retarded at more than a predetermined rate, the free flywheel flexes the leaf spring and there is an angular displacement of the two elements. When the predetermined maximum braking rate is exceeded, by a suitable margin, the displacement is sufficient to close electrical circuits which bring about the desired release of the brakes. The Decelostat is so arranged that it can perform its function when the wheel is rotating in either direction. Since the accelerations encountered with trains are less than the retardation found when the wheel slips, the Decelostat does not function during periods of acceleration.

BRAKING FRICTION

It might appear that the duration of the slipping period is so short that a slip would change to a slide before the brakes could be temporarily released. Tests have shown, however, that the slip, which persists for a time of the order of 1 sec, can be used as a signal to release the brakes and prevent a slide. The Decelostat, Figs. 1 and 2, is a recent development. Its first commercial application in the United States—and presumably in the world—is on the new *General Pershing* Zephyr of the Chicago, Burlington & Quincy Railroad.

It has been said that the retarding force at the rail is established by the braking friction produced by an application of the brakes. The friction itself, of course, comes from the brake shoes, one on each side of the wheel.

Friction, in the air-brake art, has quite a different function from friction as encountered in other fields. To engineers in general, friction is a detrimental influence and lowers the efficiency of any mechanism. In air-brake practice friction is the end result and is the output, as it were, of the braking system.

The laws governing the friction of dry, unlubricated surfaces are obscure and coefficients of friction have a wide latitude as can be observed by referring to any handbook. Generally, the lack of precise knowledge is no great handicap because the loss due to friction is not a high percentage of the total output and mistaken assumptions of f do not seriously affect the result. With brakes, the situation is quite different.

This can be easily understood by considering a hypothetical case. Suppose it is desired that the brake be designed so that the ratio of retarding force to wheel load shall never exceed 26 per cent, the maximum value for coefficient of adhesion on dry, unsanded rail, as found by Metzken. It is clear that some margin must be allowed for variable friction. Suppose it is said that f varies 20 per cent either way from the mean. An adhesion of 26 per cent permits a retardation of 5.72 mphps. With a total range in f of 40 per cent, therefore, the retardation, when f is a maximum, is 5.72 mphps and, when f is a minimum, it is 3.43 mphps. The hypothetical stop from 100 mph with the first retardation is 1280 ft and, with the second, 2140 ft or an increase of 860 ft. From this, it is quite evident that variations in friction are a problem in the brake art.

However, this problem is not mainly one of variable stop distances, because a train has a great many brake shoes and their very number tends to average out variations in individual shoes. The more serious problem is in connection with slid-flat wheels. Modern powerful brakes obviously require rail adhesion approaching the maximum. Hence consistent friction is essential and, if it is not obtained, wheel sliding is inevitable, unless Decelostats are installed.

The conventional cast-iron brake shoe is a familiar sight but not many are aware of what it is called upon to do. The con-

ventional brake shoe (when new) weighs about 25 lb and has a projected area of about 45 sq in. The braking pressure is limited to 400 lb per sq in., calculated on the basis that there is no loss in transmitting the braking pressure, or 18,000 lb per shoe. The magnitude of the frictional force the brake shoe is called upon to produce is seldom realized. With a braking pressure of 9 tons, and assigning to f a value of 0.20, the frictional force amounts to 1.8 tons. Probably in no other field is a frictional force measured in tons.

Engineers in general are accustomed to think of coefficients as constants, not variables. But the coefficient of friction for a cast-iron brake shoe is never constant and is always varying. From a great number of tests, it has been found that, under normal conditions, the coefficient of friction f decreases with increasing pressure and speed. If a number of repeat tests for a given pressure are averaged and f is plotted against speed, a hyperbolic curve, with an asymptote parallel to the speed axis, results. If the braking pressure is reduced, a curve parallel but higher is obtained; if the pressure is increased, a parallel, but lower curve, appears. All this, of course, is in accordance with the general law that f decreases with increasing speed and pressure.

Brake engineers at times are called upon to explain why it is so difficult to predetermine the stopping distance of a train. The ever-changing f, and with it the retarding force, makes the difficulty clearly evident. Newton, with his calculus, provided means to study motion uniformly or nonuniformly retarded. Without calculus, averages must be used which, of course, can lead to quite erroneous results. Newton's familiar differential equation $v\,d\,v = p\,d\,s$ is available, if the retarding force p can be expressed as a function of v and in such form that the expression can be integrated. To date, this has not been accomplished for practical road conditions.

For many years, it had been generally accepted in the brake art that f decreased with increasing speed and pressure. But, when the railroads inaugurated ultra-high-speed train operation a few years ago, a distinctly new phenomenon was encountered. This phenomenon is called "flaming" and comes about because of the intense heat produced during modern high-speed braking.

The heat developed during braking action is greater than commonly supposed. At a given speed, a train contains a certain kinetic energy or so many foot-pounds, which must be dissipated or converted into heat. If the stop is made quickly, evidently the rate of doing work (negative) is greater than if the stop is made slowly. The rate of doing work may be expressed as so many foot-pounds dissipated per second, but it is somewhat less cumbersome to employ the term horsepower or 550 ft-lb per sec.

HEAT PROBLEM IN HIGH-SPEED BRAKING

Fig. 3 illustrates the magnitude of the heat problem in modern high-speed braking. An axle load of 36,000 lb is taken, or about the maximum encountered with car axles. The speed from which the stop is made is assumed to be 100 mph. Various retardations are shown. It should be clearly understood that these retardations are constant throughout the stop and, therefore, differ from the retardations obtained in actual practice. They approximate actual conditions well enough to serve as an illustration of the problem. It will be noted that, in a stop of about 5000 ft, the maximum horsepower dissipated is about 660; and that, in a stop of about 1225 ft, the maximum horsepower is about 2600.

As previously stated, the conventional brake shoe, when new, weighs about 25 lb, and there are four of them per axle. Accordingly, in high-speed braking, the brake shoe may be called upon to dissipate momentarily up to 500 hp. Such rates of heat dissipation obviously mean that the brake shoe gets very hot; and, since there is insufficient time for much heat to be carried away by conduction, etc., the skin temperature, or that existing at the rubbing surfaces, attains very elevated values. In fact, the temperature becomes so great that oxygen from the air appears to unite with carbon in the shoe to form long yellow flames. This is the phenomenon mentioned as flaming.

It had been anticipated that the friction of brake shoes might be reduced under these conditions of extreme heat, because of reduced strength of the metal; but actually the contrary, or an increase in friction has been noted. This increase in friction, moreover, is not of a minor character but is, instead, most substantial. A tentative explanation of this marked increase in friction is that the lamina of metal in actual contact is so quickly worn away that, in effect, cool and strong metal is present at the rubbing surface. This theory is supported by the fact that flaming is always accompanied by excessive wear of the brake shoe.

Flaming is objectionable, not only because it involves rapid shoe wear and the deposit of bonded metal on the wheel tread,

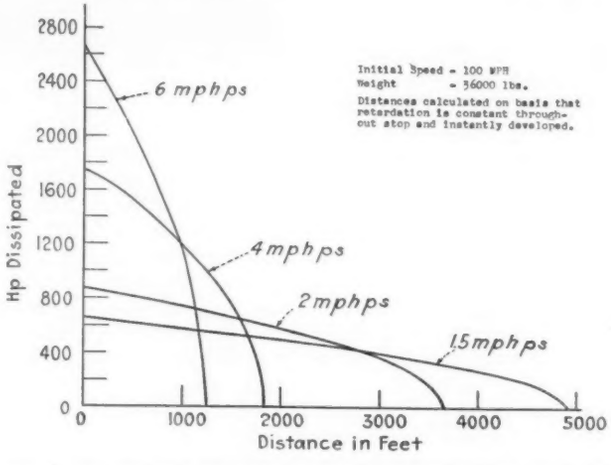

FIG. 3 MAGNITUDE OF HEAT PROBLEM IN HIGH-SPEED BRAKING
(Initial speed 100 mph; weight 36,000 lb. Distance calculated on basis that retardation is constant throughout stop and instantly developed.)

but also because it indicates a change in the character of the brake-shoe friction. This change is especially unsatisfactory in that it is indeterminate, since it depends not solely upon the horsepower being dissipated, but also upon the initial shoe temperature. Emphasis has already been given to the great desirability of consistent friction with modern high-speed brakes.

Brake shoes for modern high-speed braking are generally of greater area than those used in the past, or a single brake shoe is replaced by two smaller shoes. Unfortunately, modern research has confirmed the findings of early experimenters that dry, unlubricated friction is independent of the area in contact, other conditions remaining the same. Increased area is highly beneficial from the wear viewpoint, however, and indirectly increases friction because it reduces the amount of worn-away metal, and its lubricating effect.

The load applied to the brake shoe is a concentrated one in that it comes through a pin connection. Consequently, although more contact area may be provided, it is not certain that the pressure will spread over the entire area. In addition, the contact face of the brake shoe is the arc of a circle, so that expansion and contraction often cause imperfect bearing with localized zones of high pressure. From all of the foregoing,

it is evident that the friction-producing elements of the modern brake system have a difficult assignment.

TREAD VERSUS NONTREAD BRAKING

It is evident that the problem of heat involves the wheel as well as the shoe. There is a material difference, however, in that any given area on the wheel tread is subject only intermittently to high temperature, whereas more or less the entire face of the brake shoe must continuously withstand these high temperatures. In addition, any given area on the tread is cooled intermittently, because it is exposed to the atmosphere at high rotative speed, while the shoe is stationary and has low heat-dissipating characteristics. Notwithstanding, the intense heat generated is said by some engineers to be destructive to the wheel and to an extent that makes it imperative that braking be removed from the wheel tread when powerful braking is contemplated. Other engineers assert that wheel damage is due primarily to heavy loads and high speeds and that the scrubbing action of the brake shoes on the wheel tread is actually beneficial. The C.B.&Q. train previously mentioned is equipped with nontread brakes. Experience with it will supply facts, now lacking, as to whether tread braking is actually a serious handicap to good wheel performance, because comparisons can be made between tread and nontread braking under equivalent conditions.

BRAKE RIGGING

Pressure is delivered to the brake shoes from the brake cylinder by an assemblage of rods and levers, known as the brake rigging. Improvements have been made in this system from time to time, but serious problems are encountered with it in modern high-speed braking.

It has been previously explained that the coefficient of friction f decreases with increasing speed and pressure. To obtain tolerable stop distances with the ultra-high-speed trains, it is necessary to obtain higher than conventional braking friction at the higher speeds. Obviously, the braking pressure has to be increased to provide this higher friction; it has to be increased again to compensate for the reduction in f caused by the higher speed; and it has to be increased still further to compensate for the reduction in f brought about by this increased pressure. The net result is that the braking pressures become very high. Present practice is to apply a braking (brake-shoe) pressure, at the highest speeds of 250 per cent of its weight to the car wheel, calculated on the basis that there are no transmission losses in the rigging system. If a truck has four wheels, each loaded to 18,000 lb, it is evident that the nominal braking pressure is 180,000 lb or 90 tons. The illustration cites an extreme case but it discloses the fact that the brake rigging is called upon to handle large forces.

Since engineers in general are not familiar with the magnitude of the braking forces and since the force relationships in brake rigging are considered to have some interesting engineering features, a few typical cases will be discussed.

Fig. 4 shows a brake shoe with the forces acting upon it. These forces are three in number; first, the braking force P delivered horizontally; second, the force H in the hanger by which the brake shoe is suspended; and third, the force R or reaction from the wheel. P is the primary force and for the purposes of this illustration is taken as 18,000 lb. R the reaction from the wheel is an induced force, the line of action of which must lie upon a line from O (neglecting pin friction) and tangent to the wheel-friction circle (not shown). With the value of P given and the line of action of R known, it is possible to ascertain the value of the force H induced in the brake-shoe hanger.

In Fig. 4 (a), the coefficient of friction is taken as 0.06, which results in a tensile hanger force, of 1585 lb; and in example (b) the coefficient of friction is taken as 0.24, which gives a compressive hanger force of 1170 lb. (It should be observed that the force in the hanger does not equal the force of friction.) Example (a) serves to make clear a difficulty encountered with conventional rigging in modern high-speed service.

When an emergency application is made at high speeds, the coefficient of friction is low, say of the order of 0.06. The trailing hanger Fig. 4 (a), therefore, exerts a downward pull on the truck frame to which the hanger is attached. The leading hanger, for all values of f, always develops a pull on

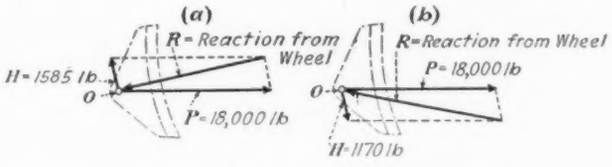

FIG. 4 FORCES ACTING UPON BRAKE SHOE

(Clockwise rotation of wheel
Center of brake head 3 in. below center of wheel
Hanger makes 12-deg angle with vertical
Thickness of brake shoe and head 4 in.
Coefficient of friction (a) 0.06, (b) 0.24
Wheel diameter 36 in.
Diagram distorted for illustrative purposes.)

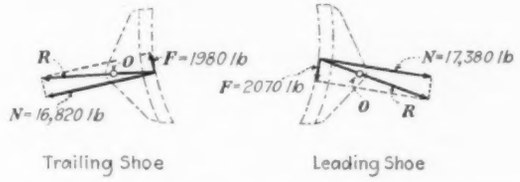

FIG. 5 FRICTION FOR BOTH LEADING AND TRAILING SHOES OBTAINED FROM HORIZONTALLY APPLIED BRAKING FORCE OF 18,000 LB

(Clockwise rotation of wheel
Center of brake head 5 in. below center of wheel
Hanger makes 20-deg angle with vertical
Thickness of brake shoe and head 4 in.
Coefficient of friction 0.12
Wheel diameter 36 in.
Diagram distorted for illustrative purposes.)

the truck frame. All four hangers are, therefore, pulling down on the truck frame and, because of the high braking forces already mentioned, with a combined force of several tons. Since the truck frame is spring-supported, it moves downward and, as the brake shoes now clasp the wheel, it cannot thereafter move upward. This is not a desirable condition, chiefly because of its interference with truck resiliency.

Fig. 5 illustrates the friction for both leading and trailing shoes obtained from a horizontally applied braking force P of 18,000 lb and with a coefficient of friction of 0.12. The wheel reaction R, shown in Fig. 4, is here divided into its two components, a normal component N, the line of action of which passes through the wheel center, and a frictional component F, perpendicular to the normal component. It will be noted that the total frictional force obtained is 4050 lb. This is 93.7 per cent of the friction indicated by applying the coefficient of friction directly to the braking force P. It will be observed that the frictional force obtained depends not only upon the value of f, but also upon the location of the pin center O, the hanger angle, the thickness of the shoe, and the radius of the wheel. On this account, it is not possible to determine precisely the braking friction obtained with conventional brake rigging. This is of greater consequence under modern conditions than in the past, because powerful modern brakes

more frequently operate near the slipping point of the wheels.

Fig. 6 illustrates why the pin-connected, conventional brake shoe has an inherent tendency to wear tapered when the wheel always rotates in the same direction. As previously explained, the resultant pressure R on the brake shoe must act along the line drawn from O tangent to the friction circle, as OA. The geometric center of the brake shoe lies on the line OB. It is clear that line OA is always below line OB, even for the lowest values of f. On this account, the pressure is concentrated at the entering end of the shoe, with the result that the shoe is

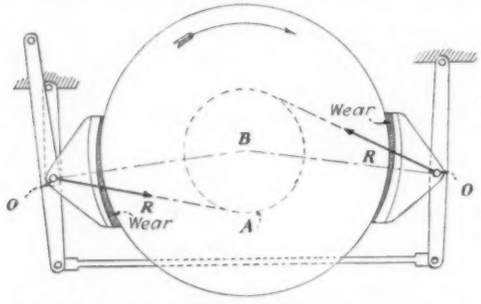

FIG. 6 TENDENCY OF PIN-CONNECTED CONVENTIONAL BRAKE SHOE TO WEAR TAPERED

worn tapered. From Fig. 6, it will be apparent that the leading shoe has likewise a tendency to wear tapered from its entering end. Such wear has actually been observed in service.

It should be distinctly understood that Figs. 4, 5, and 6 are for illustrative purposes only and that their value for practical quantitative analysis is substantially nil. The reasons for this can readily be made manifest. It has been previously pointed out that f is continuously changing during the stop. Hence the diagrams, which are based upon specific values of f, refer to conditions which exist only momentarily and may, therefore, be said to be instantaneous diagrams. A great many of them would be required to analyze the action occurring during a stop. Again, f is given the same value for each shoe, which is not consistent with actual conditions, not only because the normal reaction is not the same at each shoe, but also because f has sufficient variation to make it most unlikely that f, at a given instant, is identical for the two shoes. Also, the force diagrams depend upon the position of the brake shoe which is uncertain or indeterminate in an actual stop.

An important factor in connection with conventional brake rigging is its efficiency for, just as with belting or gearing, the transmission of braking forces is not accomplished with 100 per cent efficiency. Before braking pressures attained present high values, it was possible to compensate for transmission losses without serious penalty. However, with the pressures used in modern high-speed braking, such compensation has a decided drawback in that it further increases the weight of parts, already heavier than desired, since they are intended for lightweight car equipment.

(*To be concluded in the next issue*)

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Power *and* Fuel

(*Continued from page 582*)

Boiler-feed-pump drives of the larger of these installations may require as much as 1500 to 2000 hp. If these are operated with steam near the 200-lb level and exhausted into a heater, the steam flow required may be of the order of 30,500 to 50,000 lb per hr. Hence, the steam flows involved are of considerable magnitude and may be used to improve heat-balance layout.

Due to wide diversification in the requirements of power and process steam in the industrial field, turbines for such applications must necessarily be built to order. As a result, these turbines are designed for practically any industrial application.

In many industrial plants such as those found in the chemical industry, where in the past there has been a large demand for heat and a moderate demand for power, the developments in their processes are changing in the direction toward requiring greater increase in the power demand than in the heat. This change in ratio of kw and Btu requirements can best be made by increasing the steam pressure.

With the present developments, industrial-type machines can be built for practically any capacity desired and for steam-inlet conditions up to 2000 lb and 950 F total temperature. Capacities of those built recently continue upward with an increasing number rated as 5000 to 7500 kw. There is also a noticeable increase in the number of extraction machines in the lower ratings which formerly had been straight noncondensing. Steam conditions, likewise, are increasing and will undoubtedly continue upward as more operating experience is obtained at the levels now in use.

METERS, INSTRUMENTS, AND AUTOMATIC CONTROL

While fuel-burning equipment, boilers, turbines, and auxiliaries have been through a period of change and improvement, the entire field of meters, instruments, and automatic control in the boiler room and power plant has developed from one incorporating little more than a water column and a few steam gages into a veritable fund of information and knowledge. Some of these instruments are indicating, for momentary guidance and check by the operators, while the more important ones are integrating and recording for efficiency calculations and permanent records. The trend will be toward more instruments and wider application of complete automatic control, with increased accuracy for the more important data. This greater accuracy will apply not only to quantities such as fuel weights and steam flow, but also to air requirements for combustion and greater accuracy in the proportioning of fuel and air.

The control of the ratio of fuel and air for combustion has been guided largely with respect to thermal efficiency with variations, as dictated by slag and ash limitations. The rates of heat absorption in different parts of a furnace are also greatly influenced by the excess air. Improved operating guides are needed further to develop this phase of furnace design and operation. Better combustion guides are also needed for burning mixed fuels or alternate fuels.

SUMMARY

While changes and improvements will continue, as they have in the past, the immediate future will likely be recorded in history as a period of consolidation of the good points and advantages from recent experiences, toward more reliable operation with less stress laid on low cost of equipment or high thermal efficiency and more on dollar efficiency and sound economics.

Acknowledgment is made to the manufacturers of turbines and other equipment for assistance in preparing this paper.

The STRENGTH *of* METALS *at* ELEVATED TEMPERATURES

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KNOWLEDGE of the behavior of metals under stress at elevated temperature is becoming increasingly important to the engineer. The trend toward higher temperatures and pressures in industry arises partly from the resulting fuel economy in the production of steam power, and partly from the possibility of more efficiently carrying on chemical processes such as the cracking and polymerization of oil in the manufacture of gasoline.

The engineer finds that a metal at high temperature in many ways behaves in a manner opposite to that encountered at ordinary temperature. Instead of maintaining its shape under stresses less than the proportional limit, it flows or creeps continuously under the operating stresses. Furthermore, at high temperature, strain-hardened metal is weaker than metal free from strain; and metal made up of coarse grains resists creep better than when it is fine-grained. The contrast between the behavior of metals at high and at low temperature may be somewhat disconcerting when the customary practice is followed of designing on the basis of room-tem perature properties. However, all metals behave similarly under stress and in all metals a change of temperature produces effects which are similar in kind and differ only in degree. The reason for this similarity in behavior lies in the fact that all metals are aggregates of crystalline grains.

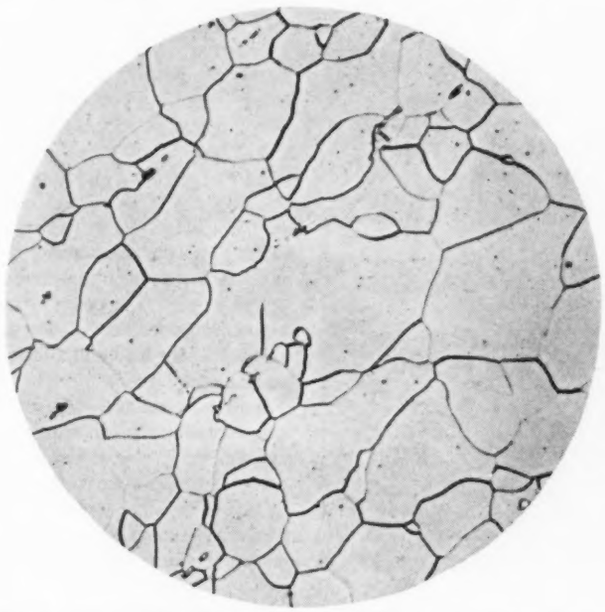

FIG. 1 PHOTOMICROGRAPH OF STRAIN-FREE, LOW-CARBON STEEL, SHOWING IRREGULAR OUTLINES OF FERRITE GRAINS
(×500, polished and etched.)

The crystalline nature of metals is not obvious to the unaided eye. Normally, a crystal is considered to be an object having symmetrical sides, such as a quartz crystal. Such perfectly formed crystal faces are rarely shown by metals because, as molten metal crystallizes and solidifies, the growing crystals interfere with each other and their final external form is somewhat irregular. Furthermore, the individual crystals are microscopic in size. In steel such as that used in automobile bodies and fenders, there are about 400,000,000 crystals per cu in. The irregular shape of the crystals and the granular appearance of fractured metal have led to the general use of the term "grains" instead of "crystals." If, instead of fracturing a piece of steel, it were cut, polished, and examined under a microscope, the outlines of the grains would appear as in Fig. 1.

Presented at a meeting of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, N. Y., March 14, 1939.

BEHAVIOR OF METALS UNDER STRESS

When a piece of metal is subjected to increasing tensile stress at ordinary temperature and the elongation is measured, a stress-strain diagram, such as Fig. 2, is obtained. The deformation is elastic until the stress reaches a certain maximum value, usually called the proportional or elastic limit *A;* upon release of any stress less than *A*, the piece of metal returns essentially to its original length. However, if the stress is increased beyond the proportional limit, as to *B*, there is a permanent change of length *OC* upon release of the stress. This permanent deformation of a metal takes place principally through a crystallographic process of slipping along certain planes within the component crystals. It is generally accompanied by a hardening and strengthening of the metal. How slipping of certain planes of atoms over one another should increase the resistance to further slip is not well understood; the slipping produces small local distortions which somehow tend to hinder further flow. In a large single crystal of zinc, $\frac{1}{2}$ in. in diameter and 6 in. long, this glide process may be observed with the naked eye, Fig. 3. This resulted from entire groups of atoms being displaced simultaneously over the entire cross section of the specimen, leaving clear-cut traces of the slip.

In a fine-grained metal such as steel, a microscope is necessary to observe the slip lines in the individual grains. When a piece of stainless steel has been stressed sufficiently to produce a considerable amount of permanent deformation, the lines of slip in the individual grains appear as in Fig. 4. It will be noted that the direction of the slip lines differs in the various grains. These slip lines are visual evidence of plastic deformation of the metal which is accompanied by strain hardening.

The phenomenon of strain hardening is generally familiar. When a piece of copper wire is bent repeatedly, it becomes stronger and more resistant to further bending. Microscopic examination of the cold-worked copper wire would show the grains to have developed slip lines similar to those in Fig. 4. All metals have this property of strain hardening. However, when a strain-hardened metal is heated, at some definite temperature characteristic of the metal, it will lose its increased

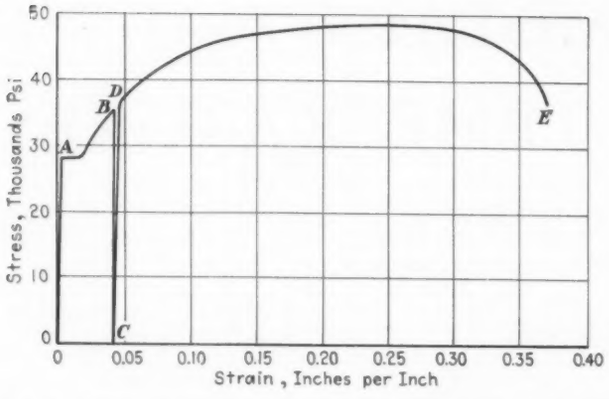

FIG. 2 STRESS-STRAIN DIAGRAM OF LOW-CARBON STEEL RESULTING FROM A ROOM-TEMPERATURE TENSILE TEST

(As load is increased, specimen stretches as indicated by curve *ABD* and breaks at *E;* if test is interrupted at *B* and load removed, permanent extension *OC* will be found.)

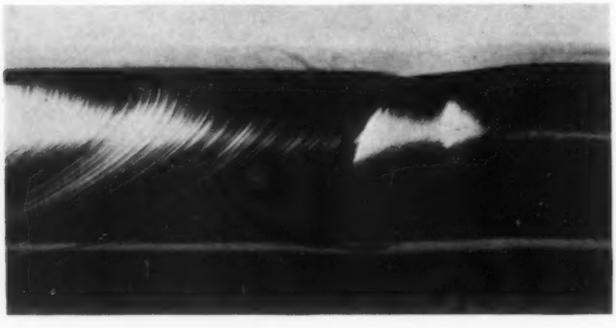

FIG. 3 SINGLE CRYSTAL OF PURE ZINC WHICH HAS BEEN STRETCHED IN TENSION TO PRODUCE SLIP LINES

(Original crystal $\frac{1}{2}$ in. diam, 6 in. long; ×2.)

FIG. 4 STAINLESS STEEL AFTER COLD WORKING TO PRODUCE SLIP LINES IN GRAINS

(Note that direction of slip lines differs in various grains; slip lines are visual evidence of strain hardening; ×500.)

hardness and strength and again become soft. This is also familiar, for it is well known that copper wire, hardened by repeated bending, may be softened by heating it to a low red heat. The temperature at which strain hardening begins to disappear is commonly known as the "recovery" temperature.

EFFECT OF TEMPERATURE ON METALS UNDER STRESS

When a metal is stressed beyond its elastic limit, two opposing processes, strain hardening and softening, always take place. At low temperature, softening is very slow and strain hardening predominates. As the temperature increases, the rate of softening or tempering becomes greater and the rate of strain hardening becomes less. At some temperature, these two opposing processes balance each other. At higher temperatures, some strain hardening can still take place, but tempering is so rapid that the softening effect predominates. The temperature at which the two opposing processes balance may be called the "transition temperature." Since the rate of straining affects the relative speed of these two processes, the transition temperature of any one metal is not a single fixed temperature, but may vary over a considerable temperature range. It is a characteristic of the metal, and does not necessarily occur at high temperature; e.g., for lead it is below room temperature. The creep of a lead roof under its own weight is a common occurrence. For the ordinary structural metals and alloys, except lead and zinc, the transition temperature is above room temperature.

The fundamental difference between the behavior of most metals under a given applied stress at atmospheric temperature and at elevated temperature is that at atmospheric temperature most metals begin to flow but are gradually strengthened by strain hardening and finally cease to flow, whereas at any temperature above the transition temperature they continue to flow. This continued flow of metals under stress at high temperature is called "creep." In either case, if the stress is increased sufficiently, the metal will break.

Fortunately, the rate of creep of a metal at temperatures above its transition temperature is proportional to the stress. A negligible amount of creep or change of shape may usually be achieved by limiting the applied unit stress by correct design. Fortunately also, some metals or alloys are more creep-resistant than others. If a high unit stress is unavoidable, a more creep-resistant material may be employed. It is necessary to investigate the relative rate of creep of different materials over a range of temperatures and unit stresses.

This transition temperature is approximately the same as the recovery temperature. Some investigators have referred to it as the "equicohesive" temperature, which was originally employed by Jeffries and Archer in their discussion of the effect of temperature and stress on the relative strength of the grains and grain boundaries of metals.

METHOD OF DETERMINING CREEP RESISTANCE OF STEELS

The method of measuring the amount of creep shown by any given metal or alloy under a certain stress and at a certain temperature during a fixed time period, is simple enough in principle, but in practice it requires special apparatus and equipment, and great care and precision in the observations. Since the creep rates of commercial interest are of the order of 0.000001 in. per in. per hr, or less, sensitive and dependable measuring instruments must be used, and the temperature of the specimens must be precisely controlled within very narrow limits over extended time periods.

The method almost universally employed in this country is essentially as follows: A specimen of the metal, held at constant temperature in an electric furnace, is subjected to a static tensile load. The load causes the specimen to elongate

gradually, the amount of elongation being measured periodically. The total elapsed time of each test may be a matter of hours, weeks, or months. Some creep tests have been run for more than 5 years. There has been considerable argument as to the maximum testing time for reliable indications, but most investigators are now agreed that this is to be reckoned in terms of hundreds, or even of thousands of hours.

At the Research Laboratory of the United States Steel Corporation, Kearny, N. J., the specimen of steel to be tested is a slightly modified tensile-test specimen, machined to the shape *A*, Fig. 5. Indicating arms *B* are attached to the specimen as in *C*, in order to refer the amount of elongation taking place in the gage length to a common point for measurement with a micrometer microscope. The assembly is then screwed into cast-alloy-steel pull rods *D* and the unit is slipped into a tubular, specially wound, electric-resistance furnace. The specimen, surrounded by its furnace is anchored at the bottom, and attached to a lever at the top and held in a steel framework, Fig. 6.

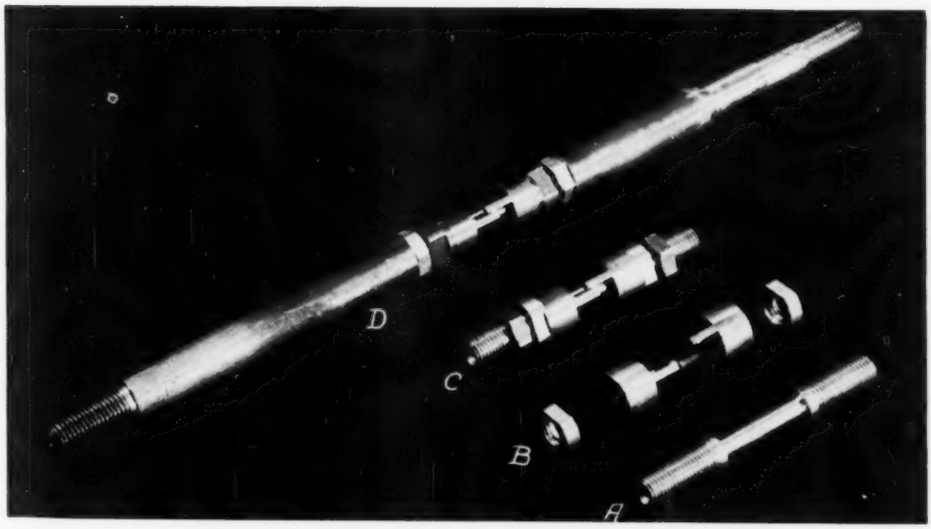

FIG. 5 CREEP TEST SPECIMEN *A*, INDICATING ATTACHMENT *B*, AND COMPLETE ASSEMBLY *C* AND *D* USED IN CREEP TESTING AT RESEARCH LABORATORY OF UNITED STATES STEEL CORPORATION

(Platinum-iridium beads welded to tips of 27 per cent chromium indicating arms, and polished and engraved with fine reference marks in form of crosses.)

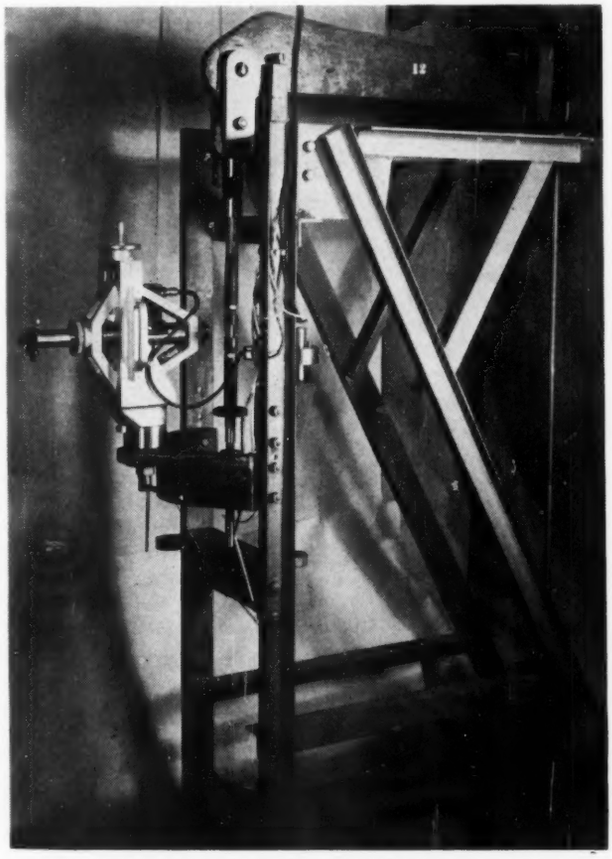

FIG. 6 CREEP-TESTING APPARATUS USED AT RESEARCH LABORATORY OF UNITED STATES STEEL CORPORATION, SHOWING MEASURING MICROSCOPE IN READING POSITION

(For clarity, the tubular electric-resistance furnace is not shown.)

When the specimen is loaded by hanging weights on the lever, the extension taking place in the specimen is brought to a single point by the indicating arms, on each of which is welded a platinum-iridium reference surface carrying fine engraved reference marks in the form of crosses. The appearance

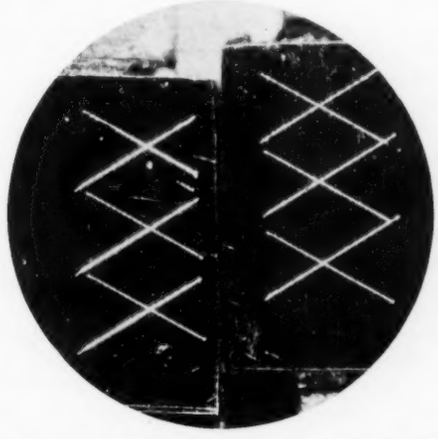

FIG. 7 PLATINUM-IRIDIUM REFERENCE SURFACES ATTACHED TO INDICATING ARMS OF CREEP SPECIMEN AS SEEN THROUGH MICROMETER MICROSCOPE

(Crosses are actual reference marks; ×100.)

of the reference surfaces as seen through the measuring microscope is shown in Fig. 7. During the creep test, one of the pairs of surfaces moves vertically relative to the other. By measuring the relative vertical displacement of the reference marks with the micrometer eyepiece of the microscope, shown in reading position in Fig. 6, the amount of elongation which has taken place in the specimen is measured to an accuracy of about ±0.00001 in. per in. on a 2-in. gage length. The temperature is held within ± 1 F over the gage length of the specimen and

from day to day during the $4^1/_2$-month test period, since a change of as much as ± 2 F would cause sufficient thermal expansion or contraction to introduce an error into the readings. Such accuracy is necessary since an attempt is being made to determine in a relatively short time period ($4^1/_2$ months) the stresses which will produce a total change of length corresponding to about 1 per cent in 10 years.

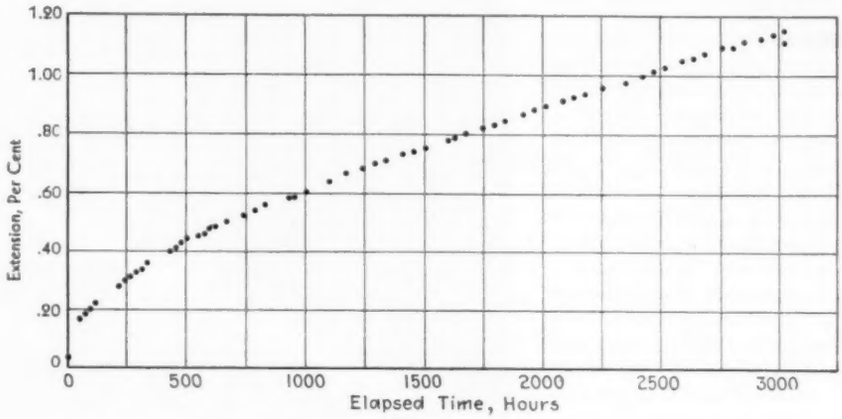

FIG. 9 ACTUAL CREEP CURVE OF ALLOY STEEL UNDER STRESS OF 10,000 PSI AT 1000 F

SHAPE OF THE CREEP CURVE

When the change in length in a specimen from day to day is plotted against the elapsed time, a creep curve, shown schematically in Fig. 8, is obtained. This curve comprises five fairly distinct zones. When the load is first applied, there is an immediate elastic extension *A*. The specimen then begins to stretch gradually at a decreasing rate *B*, followed by a period *C* of approximately constant creep rate. This in turn is followed by a period *D* of increasing creep rate and, finally, when the load is removed, there is an elastic contraction *E*, corresponding to the initial elastic extension upon application of the load at the start of the test. The amount of permanent change of length *F* may be read from the creep curve. It is thus apparent that metals creeping under stress at high temperature can and do show both plastic and elastic properties simultaneously.

The exact shape of an individual creep curve depends on the stress employed and upon the temperature, as well as upon the composition and structure of the metal. While elastic extension and contraction are always found at the beginning and end of the test, it is rare in any one test to find periods of decreasing, constant, and increasing creep rate. An actual creep curve for a steel at 1000 F under a tensile load of 10,000 lb per sq in. is shown in Fig. 9.

DETERMINATION OF NOMINAL CREEP STRENGTH

The fact that a given steel proves to have a certain creep rate at the end of a stated time period, under a particular stress and at a specific temperature, may be of interest, but it is of little practical importance, since in many cases the creep rate is continually changing with elapsing time. What engineers building equipment to operate at elevated temperature must know is the safe working stress which the metal will withstand without creeping to an undue extent during the life of the part. Two standards are commonly used in this country, (*a*) the stress producing a creep rate of 1 per cent per 10,000 hr (a little over a year), or (*b*) the stress for a creep rate of 1 per cent per 100,000 hr (about 11 yr). This second standard is used in designing moving parts such as steam turbines, in which the total creep must be very small, a fraction of 1 per cent in 20 years.

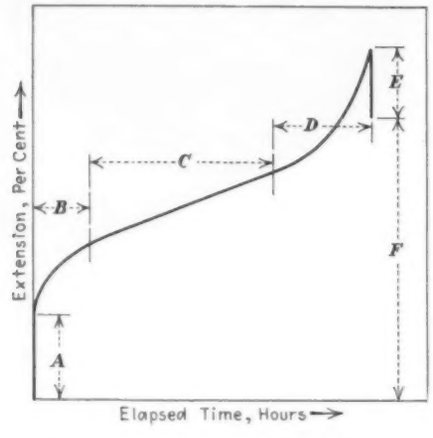

FIG. 8 SCHEMATIC CREEP CURVE—EXTENSION PLOTTED AGAINST ELAPSED TIME

(*A* Elastic extension; *B* creep at decreasing rate; *C* creep at approximately constant rate; *D* creep at increasing rate; *E* elastic contraction; *F* permanent change of shape.)

The limiting permissible stress for each material must be ascertained by experiment. This is done in the following manner: Several creep tests are run under different stresses at a single temperature and the creep curves plotted on the same chart. A family of curves such as that shown in Fig. 10 results. Points *a*, *b*, *c*, *d*, and *e* indicate the beginning of the period of increasing creep rate for each stress, and a curve *RS* can be drawn through these points. It is evident that, for the stress used on curve *F* or *G*, an increasing creep rate would not be encountered for an extremely long period. Therefore, a stress of this magnitude could be used with safety in designing apparatus to be made of this material. It has been found by experience that the creep rate of curves such as *F* and *G* is of the order of 1 per cent per 10,000 hr or 1 per cent per 100,000 hr, respectively. The stresses for these creep rates have therefore been generally selected for design purposes.

In Fig. 10, the line *MN* represents the end of a testing period which is too short to show the true long-time behavior of the material, since the later increase of creep rate in curves *D* and *E* would not have been detected, and the useful strength of the material would have been overestimated. For accurate determination of long-time creep strength, standard testing periods of from 1000 to 3000 hours are now generally employed to overcome this difficulty.

In practice, three or four tests on any given material have been found sufficient to indicate its behavior at a given temperature. The creep rate at the end of the test period is plotted against the applied stress. The stress for a nominal creep rate of 1 per cent per 10,000 hr or 1 per cent per 100,000 hr is obtained by interpolation. When such a series of tests has been run at a variety of temperatures, the stress for a nominal creep rate may be plotted against the temperature, as in Fig. 11, which shows the influence of temperature on the creep strength of several steels commonly used for high-temperature service.

In actual use of this information, the design stress is never as high as the reported creep strength of the material. The magnitude of the factor of safety will depend upon the proved per-

formance of the material already in service and upon the confidence of the engineer in the available creep data.

VARIABLES WHICH AFFECT CREEP STRENGTH

Grain Size. In considering some of the major variables which affect the creep strength of metals, the question arises as to the influence of grain size. Data now becoming available indicate that above the transition temperature of the metal, the creep strength is greater the larger the grains. This is opposite to what is found at ordinary temperature, where, as is well established, a metal is stronger the finer the grain size. This reversal in behavior comes about because, above the transition temperature, the grain boundaries are weaker than the grains themselves, whereas at lower temperature, the grain boundaries are stronger than the grains. A fine-grain metal, having a greater area of grain boundaries for the same volume than a coarse-grain metal, is weaker above the transition temperature and stronger below it. Reasoning in this way, it follows that a metal would show the greatest resistance to creep when it consists of a single crystal. Practically, there are great manufacturing difficulties to surmount in making metal parts comprising only a single grain; furthermore, other important properties are injured by too great coarsening of the grains. The only commercial application of single crystals is in a few types of tungsten lamp filaments. However, a certain coarsening of the grain size in steel can be effected without impairing other properties to any significant extent; and the creep strength is definitely raised thereby.

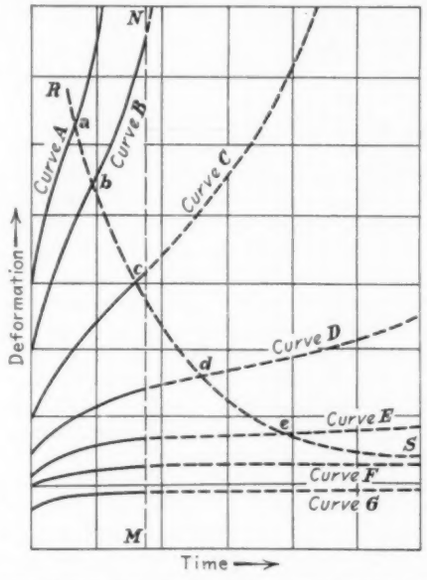

FIG. 10 SCHEMATIC PLOT OF TYPICAL CREEP CURVES FOR SEVEN SPECIMENS OF THE SAME STEEL

(Each specimen tested under a different stress ranging from a very high stress, curve *A*, to a very low stress, curve *G*, at a constant temperature.[1])

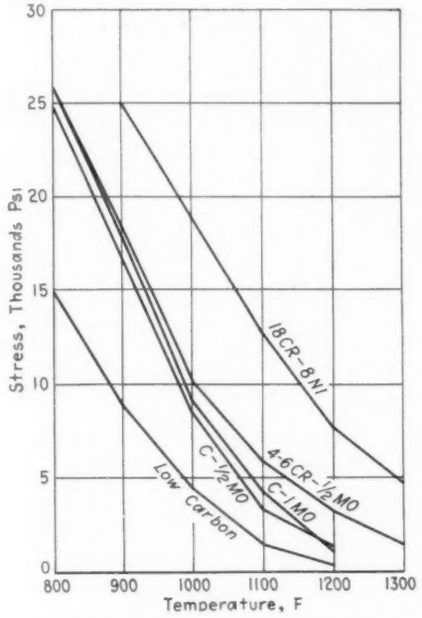

FIG. 11 COMPARATIVE CREEP STRENGTH OF ALLOY STEELS

(Stress for a creep rate of 1 per cent per 10,000 hr plotted against temperature of test.)

[1] "The Interpretation of Creep Tests," by P. G. McVetty, Proceedings, American Society for Testing Materials, vol. 34, part 2, 1934, pp. 105–116.

Heat-Treatment. Another variable which has a marked effect on the creep strength of steel is prior heating and cooling of the metal, whether applied intentionally as a heat-treatment or as a final step in making the product. If all metals were used as pure elements, the only effect of heat-treatment on creep strength would be through changing the grain size. However, commercial steels are complex alloys, and the size, shape, and distribution of the carbide particles within the grains or in the grain boundaries have a great influence upon the creep strength. For example, when sections of the same bar of a low-carbon 0.50 per cent molybdenum steel are heat-treated in different ways, it has been found possible to vary the creep strength of this particular material by from 30 to 40 per cent. The weakest condition with respect to creep was found when the steel was air-cooled from 1650 F, giving a microstructure consisting of ferrite and pearlite, Fig. 12. The clear white areas are ferrite or relatively pure iron and the shaded areas are pearlite, which is made up of alternate layers of ferrite and the iron-carbide Fe_3C. This ferrite-pearlite microstructure is unstable at 1100 F. After 30,000 hr service in an oil-cracking-still tube, the pearlite gradually spheroidized and fine particles developed in the ferrite, as shown in Fig. 13. A similar though somewhat less pronounced change of microstructure has been observed during the 3000-hr creep tests at 1100 F. This slow change of structure is associated with an acceleration of the creep rate. The danger in this is that material, which shows structural change during service, may well have a lower creep strength after several months of use than it had when the part was designed and built. The present belief is that parts for use at elevated temperature should be heat-treated at the start so they will have a stable microstructure at their service temperature. In addition, parts should be designed on the basis of the strength of this stable structure.

Previous Strain Hardening. Another example of lack of structural stability is strain-hardened, cold-worked metal. It has been known for some time that strain-hardened metal is weaker at high temperature than metal which is free from strain-hardening. The reason is that the metal is being operated at a temperature above its recrystallization temperature. The previous strain hardening facilitates recrystallization. Since creep itself is at least partly a crystallographic rearrangement of

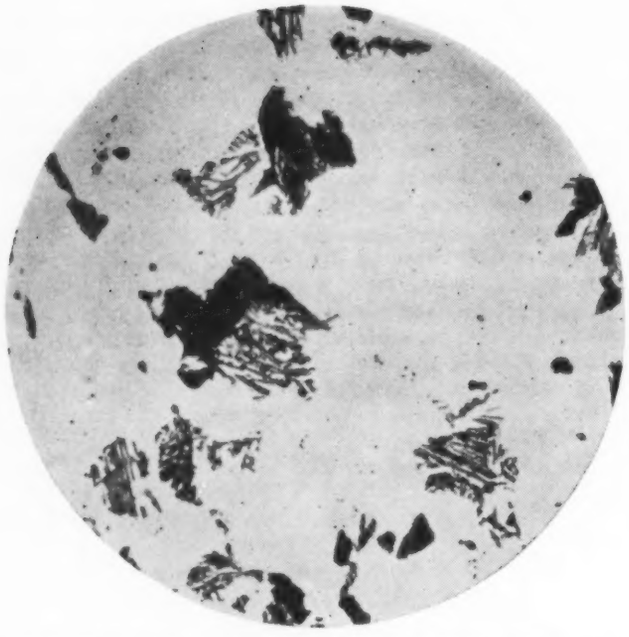

FIG. 12 MICROSTRUCTURE OF LOW-CARBON, 0.50 PER CENT MOLYBDENUM STEEL, AIR-COOLED FROM 1650 F; ×1000

atoms, any force which tends to speed up this rearrangement will also speed up the creep rate.

Short-Time Tests. One point which should be emphasized is that short-time creep tests are inadequate to indicate accurately the long-time creep behavior of the metal (see Fig. 10 and explanatory text, page 592). Short-time creep tests may tell us that some materials are relatively stronger than others over the period of the test, but they tell little that is not given by an ordinary tensile test on the metal at high temperature. Obviously they cannot show the effects of slow changes of microstructure unless sufficient time is allowed for the changes to occur. Hatfield's time-yield and the standard German creep test, which deal with the amount of creep between the thirtieth and fortieth hours after loading, cannot show the effect of a structural change which would not occur at the test temperature until several weeks after application of the load. Extrapolation from such short-time creep tests generally leads to abnormally high nominal creep strengths, and is to that extent dangerous.

SUMMARY

Since in the past there have been several standard testing periods and, since the material being tested in one laboratory has varied in analysis, grain size, and heat-treatment from nominally identical material under test in another laboratory, there has been considerable disagreement in results reported as the creep strength of a steel of a given composition. In view of this disagreement, the only figure for material of a given composition at a given temperature which the design engineer could safely select was the lowest value of creep strength reported. The situation is now improving. The variables which must be controlled in manufacturing, heat-treating, and testing are becoming better understood. The reported creep strengths of similar materials tested by different investigators now agree in most cases within 1000 psi. There is every prospect that substantial agreement on all material will be generally attained in the near future.

Even though the figure selected as representing the creep strength of the material may in some cases be higher than its true long-time creep strength, actual design stresses always include a factor of safety. Since the creep rate decreases rapidly with decrease of stress, the amount of creep in most structures used at elevated temperatures is negligible, and failure rarely results from creep alone. Failures in parts used under stress at elevated temperature generally occur because of corrosion, excessive local overheating, or a combination of alternating stresses, corrosion, and creep. Failure due to corrosion generally means that the alloy content of the metal has been too low for the particular application. Excessive local overheating may be due to an accumulation of reaction product which decreases the rate of heat transfer, or to improper furnace design and flame impingement. Whenever parts are subjected to alternating stresses at high temperature, corrosion fatigue may cause early failure.

Research on the behavior of metals at elevated temperatures has not only shown how to avoid failures, but it has led to the development of new and stronger steels. The value of this research work is demonstrated in a striking way by the increased fuel economy being reported by central generating stations which are now able to raise steam temperatures to the neighborhood of 950 F and pressures as high as 1500 lb per sq in. because of the stronger steel alloys now available. In some cases the generating-station heat rate has been reduced from about 21,000 to 12,000 Btu per kwhr.

In conclusion, the creep strength of specimens taken from a single piece of steel can be determined quite accurately and reproducibly, as was demonstrated by the cooperative creep tests on carbon steel sponsored by the A.S.M.E.–A.S.T.M. Joint Research Committee on the Effect of Temperature on the Properties of Metals. However, the creep strength of *supposedly* similar material obtained from different sources may vary within wide limits if the chemical composition, heat-treatment, and grain size are not closely controlled. Design engineers should bear in mind these limitations. The true operating creep strength of any material is that which it has when in the condition it would ultimately assume after several months of service.

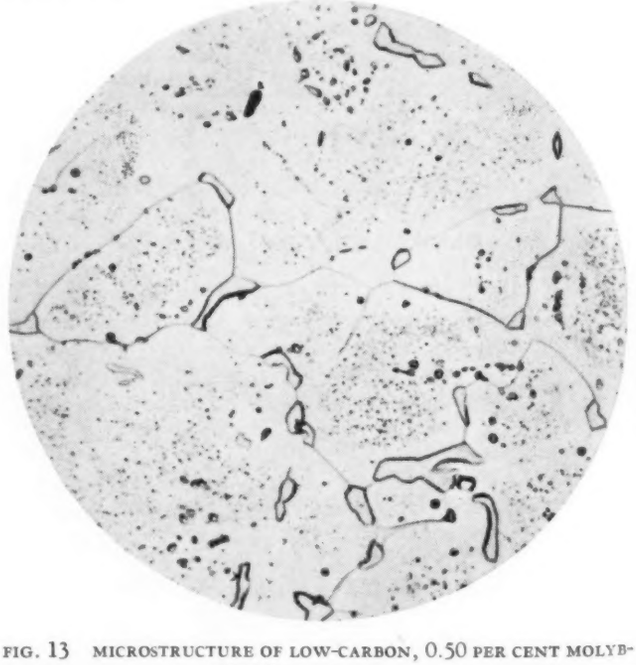

FIG. 13 MICROSTRUCTURE OF LOW-CARBON, 0.50 PER CENT MOLYBDENUM STEEL AFTER 30,000 HR SERVICE IN OIL-CRACKING-STILL TUBE AT 1100 F

(Original structure of this steel was similar to that shown in Fig. 13; iron carbide of pearlite has agglomerated at grain boundaries and fine particles have appeared within ferrite grains; ×1000.)

Cooperative Work of the
A.S.M.E. BOILER CODE COMMITTEE

Greetings of the Boiler Code Committee to the National Board of Boiler and Pressure Vessel Inspectors

By D. S. JACOBUS[1]

IT IS indeed a pleasure to meet you all again and extend the greetings of the Boiler Code Committee. Your organization is working hand in hand with the Boiler Code Committee. The cooperation of the two groups is well recognized as is brought out in the foreword of the Power Boiler Code, which reads in part as follows:

> The National Board of Boiler and Pressure Vessel Inspectors is composed of chief inspectors of states and municipalities that have adopted the Boiler Code. This Board, since its organization in 1921, has functioned to administer uniformly and enforce the rules of the Boiler Code. The cooperation of that organization with the Boiler Code Committee has been extremely helpful. Its function is clearly recognized and, as a result, inquiries received which bear on the administration or application of the rules are referred directly to the National Board. Such handling of this type of inquiries not only simplifies the work of the Boiler Code Committee, but action on the problem for the inquirer is thereby expedited. Where an inquiry is not clearly an interpretation of the rules, nor a problem of application or administration, it may be considered both by the Boiler Code Committee and the National Board.

We have worked together since you organized and so far all final actions on matters which have come before the Boiler Code Committee have been unanimous. It would have been impossible to work in this harmonious way had it not been for the mutual friendship which exists and the willingness of those who take part to consider the viewpoint of the others. It is hoped that it may be possible to continue this unanimous action even though the work has been broadened by including many additional elements.

In reviewing the work of the past it is clearly evident that the spirit which pervades the work of the Boiler Code Committee has much to do with its success.

The efforts to remove John Stevens from the chairmanship of the committee did much to promote close friendship between the members. Stevens was accused of many things by his enemies in the early formation of the code, but not once of dishonesty. The committee fought to a man for his retention and a spirit of loyalty was engendered which has continued to the present day.

Fred Low, the second chairman of the committee, was beloved by all on account of his kindliness and keen insight into human nature which, coupled with his sound engineering judgment, made him an ideal guide for the committee. Throughout his illness he asked many times about the doings of the committee and in his last spell of consciousness a day or so before he died he requested me to remember him to the boys on the committee, who he said were "a great bunch."

Such is the spirit of loyalty which, coupled with the guidance and backing of our parent organization, the American Society of Mechanical Engineers, and the cooperation of many other groups and interested parties, has led to the success of our work.

The cooperation of the steel-making industry and the A.S.T.M., and many manufacturers and experts was secured in preparing the first code and this has continued up to the present time.

There has been full and complete cooperation between the American Welding Society and the Boiler Code Committee on all matters bearing on welding. The use of fusion welding has advanced rapidly but there are many problems still to be solved. This is brought out clearly in the work of the Special Committee on Extension of Fusion Welding Requirements, which has prepared rules for broadening the field of application of welding and has worked with other committees to simplify the rules for qualification of welding processes and for testing welding operators. It is proposed to replace the corresponding rules now in the code with the new rules to make them uniform, which will do much to simplify procedure.

All the other subcommittees and special committees of the Boiler Code Committee have done excellent work. The Special Committees on Alloyed and High Tensile Steels for Welded Pressure Vessels and on Approval of New Materials have assisted the Boiler Code Committee in assigning the various uses to which materials may be put. The Subcommittees on Ferrous and Nonferrous Materials have established the allowable working stresses for different temperatures. The Special Committee on Clad Vessels has been active in establishing rules bearing on the construction and use of such vessels.

The Special Committee on Safety Valve Requirements has prepared revisions which were adopted covering testing and stamping of safety valves and has completed a painstaking investigation. It has prepared a revised table of minimum areas of openings in fire-tube boilers for safety-valve connections.

The Subcommittee on Welding has been particularly active, as well as the Subcommittee on Special Design. The Subcommittee on Material Specifications has had a busy year. All this work has thrown considerable labor on the Special Committee on Coordination, the duty of which is to coordinate all of the different rules. The last year has certainly been a most active one, and has called for a vast amount of time and effort from the members of the Boiler Code Committee and those who cooperate in the work.

As you know, the members of the Boiler Code Committee act in their individual capacities and not as representatives of any organization or industry, but this does not interfere with the committee's cooperating as a whole with other groups and organizations. Three organizations have appointed con-

[1] Advisory Engineer, The Babcock & Wilcox Co., New York, N. Y. Hon. Mem. A.S.M.E., Chairman A.S.M.E. Boiler Code Committee.

Address delivered at meeting of the National Board of Boiler and Pressure Vessel Inspectors, New York, N. Y., May 15, 1939.

ference committees for assisting in the work of the Boiler Code Committee, these being The American Society for Testing Materials, The Association of American Steel Manufacturers Technical Committees, and the American Welding Society. A movement is now under way to reorganize the work of the Boiler Code Committee and the question of additional conference committees, subcommittees, and special committees, as well as the personnel of these committees will receive most careful consideration.

Progress is being made in revising Section VIII to include certain provisions of the API-ASME Code and to prepare a code for unfired pressure vessels which will be applicable to the different industries. The first section of the revised code is on general requirements for all types of vessels, and the second on requirements for fusion-welded vessels. Proposed revisions of these two sections were sent to the members of the special committee about three weeks ago and the remaining sections will be forwarded within a few days, so that the foundation on which to build any further additions that may be deemed necessary will soon be completely in the hands of the special committee. It is proposed to hold another meeting of the special committee within a comparatively short time with a view of making definite progress toward the completion of the draft. After the draft is completed it is proposed to publish it in proof form, to forward copies to interested parties, and to hold public hearings if considered necessary.

The revision of Section VIII will no doubt tend toward its universal use by those states that have adopted the Power Boiler Code. It will be of great importance in connection with the Code for Unfired Pressure Vessels to continue the cooperation that has been secured from the petroleum, chemical, refrigerating, compressed-gas, and other industries.

An agreement was finally reached respecting the gages of tubes for water-tube boilers and a table and formulas were published in MECHANICAL ENGINEERING with the request that criticisms or suggestions be submitted to the Boiler Code Committee. So far no criticisms have been received, and it is hoped that the proposed table and formulas for wall thicknesses for different pressures will be acceptable.

It is interesting to note that features which have been discussed in the past again come before the Boiler Code Committee. In the preparation of the first code there was much discussion on how far it should go into details. It was finally agreed that the fundamental features should be covered, leaving a number of details to the judgment of the designer and the inspectors. As time went on questions that were asked and replied to in the form of interpretations were embodied in the code and many details were added. We should make sure that we do not interfere with the clarity of the code by going too far in this direction.

In the older as well as in the present rules the ductility of the material is an important element as the strains in any overstressed part are reduced through the elongation of the material when the yield point is exceeded and this tends to equalize the stresses. The ideal way would be to employ a construction which would avoid or minimize stress concentration. With a structure so designed as to avoid undue stress concentration at any point it would be feasible to base the working stresses on the yield strength rather than on the ultimate strength of the material and allow higher working stresses for some grades of material than when they are based on the ultimate strength. This brings up a question that was thoroughly discussed in the formulation of the first code, when there was a movement on the part of some to base the allowable working stresses on what was then known as the elastic limit rather than on the ultimate strength. This question has been raised again in connection with new materials now being considered by the committee and it is mentioned at this time to show the breadth of the work still before the Boiler Code Committee.

We should remember that the Boiler Code Committee was established to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service. The committee was instructed to consider the views of the manufacturers and the users as well as the scientific features of the problem. In all of the work it receives substantial aid from the National Board of Boiler and Pressure Vessel Inspectors. As I have said on many previous occasions, it is hoped that our two organizations may continue to appreciate the necessity of cooperating to the fullest extent with each other and that this cooperation and the spirit of mutual dependence and trust may be continued for many years to come.

Nesmith, New York

CHECKING WORK IN PROGRESS

MANAGEMENT *in the* SMALL PLANT

By LILLIAN M. GILBRETH

CONSULTING ENGINEER, MONTCLAIR, N. J.; PROFESSOR OF MANAGEMENT, PURDUE UNIVERSITY. MEM. A.S.M.E.

SMALL PLANTS, like small businesses, play an important part in industry today. While each one may seem to demand only a limited investment of money, time, and energy, the complete budget for the entire country is enormous. This makes important the matter of adequate management. So does the fact that the small plant offers an excellent opportunity for experiment with management technics, as well as for the training of personnel.

In the field of scientific management, the pioneer effort was made principally in small plants. For example, the work of Taylor at the Tabor Manufacturing Company and the Link-Belt Company in Philadelphia, and that of Gilbreth at the New England Butt Company in Providence, constitutes applications of the principles and practices of scientific management in plants large enough to furnish adequate opportunities yet small enough to permit keeping the project under adequate control.

SOME FACTORS THAT AFFECTED EARLY MANAGEMENT INSTALLATIONS IN THIS COUNTRY

In the light of present-day problems, it may be profitable to list some of the factors in these early management installations. Top management, in the several cases cited, headed respectively by Wilfred Lewis, James M. Dodge and John G. Aldridge, was not only sympathetic but in every instance consisted of trained mechanical engineers anxious to add management technics to the other technics of engineering. Money was available in that the industries were adequately financed, the products were marketable and in demand, and there was willingness to invest whatever amount might be needed for the introduction of scientific management. There was support for practical research and a readiness to experiment, if that were necessary. Industrial relations were stable and of such a nature that it was possible to introduce changes without fear of strikes or industrial unrest.

The personnel in its entirety was given an opportunity to participate, which induced a feeling of pride in the completeness of the installation and of the interest and commendation which it received. In their generosity, the sponsors made certain that credit be given where it was due, and that the results be presented to technical and nontechnical groups by those who had done the work, as well as by those for whom it was done. A public-spirited attitude made available all useful data, wherever it could be demonstrated that the information would be profitably applied.

On the other hand, in these early installations, even in shops where industrial relations were satisfactory, there were reverberations of industrial wars. Fear was expressed as to the effect technological improvements might have on the volume of employment, the hours of work, wages, speeding up of production, and other matters of controversy and suspicion, which had existed in the minds of labor for many years. Scientific management was new, was different, was either not understood at all, or misunderstood in many quarters. Where it was understood, there was a tendency to expect too much of it and to expect results too rapidly. Recognition by the technical group and publicity, well-intended but far too great in volume and not discriminating in character, made it difficult to do the slow and careful groundwork required. An influx of visitors slowed up work and precluded normal conditions. Inadequately trained operators, suspecting a new opportunity, attempted to copy the work of the originators or to invent competing and unsatisfactory technics. Resulting failures in installation, caused by a diversity of these elements, made it difficult to convince uninformed people of the validity of the work done.

Because of the assets and in spite of the liabilities, the installations in the pioneer small plants even today constitute valuable sources of material for anyone interested in small-plant management.

TECHNIQUES AVAILABLE TO SMALL PLANTS

It may perhaps be profitable to check the problems of a typical small plant against the framework of management and the various techniques now available and in use. It will be understood that this does not furnish a prescription for the most efficient introduction of adequate management, but it may point out pitfalls to be avoided and possible advantages to be gained. The first task of the engineer on any project is to state his problem in exact, simple, and easily understood terms. Frequently, this is easier to do in a small plant than in a larger one. If the engineer attempting to state the problem is inexperienced, or has had experience with large projects only, he may be surprised and disappointed at the relative size of his project. It will encourage him to find out how many large industries are conglomerates or organizations of small units no larger than his own. He may also discover that many projects much larger in size, personnel, and gross profit are little or no larger in net profit which, after all, is one of the chief objectives of any industrial effort. The more completely the problem can be stated, the greater will be the help when it comes to setting up or to evaluating the management.

During the last few years, valuable papers on maximum and minimum appropriate size of various industrial projects have been given at international, national, and local management meetings. Such presentations serve not only as an aid in evaluating a project but also in learning the technique and the vocabulary by which the problem may be stated in such a way that it can be evaluated. Naturally, here as in many other places, experience is of tremendous value. However, a keen interest and an alert mind can make it possible for even an inexperienced person to do a worth-while job in making his problem clear to himself and to others.

GATHERING AND CONSULTING DATA

It is likely that the data available will be incomplete, making it necessary to gather information on markets, trends, and detailed as well as over-all cost. It is far better to spend whatever time is necessary in gathering essential data at the inception of a project, than to rush in without being properly informed and then face inevitable and costly delays while the facts are being accumulated, or perhaps make serious mistakes. "What are we going to do in this industrial project?" and "Why are we going to do it?" should be questions requiring adequate answers before attempting to cope with such questions as who, where, when, and how. The recurrent and fundamental question which management always asks—"Is it necessary?" is applica-

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ble here, because on the answer depends much of the validity and stability of the project.

When it has been determined exactly what is to be done, all available information on similar industrial projects should be consulted. The important word here is "similar," because often management problems which are practically identical occur in industries which have different names, make different products, and which may seem to be in no way related. For example, industries which turn out a high-quality product furnish similar problems. Industries which are highly fashioned, highly competitive, isolated, seasonal, or have other special qualifications may be more like one another than other industries making products which fall under the same classification or employ workers who go under the same designation. It is here that all of the transferable experience of the management expert is useful as he decides specifications of the finished product, work methods, men, machines, material, and other factors of production. Many problems not mentioned have to do with supplying adequate financing, planning, recording, and maintenance of those things which go into the finished product, and with the satisfaction of the personnel which makes it and the public which uses it.

ADVANTAGES AND DISADVANTAGES OF SMALL PLANT

The small plant has an advantage over the large one, in that it is possible for more members of its organization to have a fairly good idea of its problems in a diversity of fields. Many people can know the market, the way in which the plant is financed, the technics of control and of planning, and the interrelation between design, production, distribution, and consumption. As a knowledge of these things not only adds interest and variety to the life of everyone who has it, but also prevents mistakes, irons out differences, and results in economy and in satisfaction, it is well worth while.

The small plant faces certain problems because of its size which have advantages and disadvantages. Sometimes there is a tendency to want to add to existing facilities or to expand buildings because of pride in size. This not only means increased expense for the additions but a tendency to spread out the work to fill up the space, with resulting cost in money and in fatigue. There is also frequently a tendency to underdevelop techniques of management because of the feeling that they will be too expensive and complicated for the small plant. On the other hand, there is sometimes a tendency to overdevelop, with an understandable desire to make use of every facility possible and to match up with the representatives of larger organizations as they are encountered at technical meetings.

The advantage of functionalizing the work is equally as great in the small as in the large plant. However, very often many functions must be undertaken by one person rather than each function being delegated to one individual or even to a group, which does nothing except work in it. This necessitates developing the difficult technique of shifting from one function to another, keeping the work separate, yet completely integrating it into the management plan. Such devices as a workplace for each function or a time for doing it are of assistance. So are frequent conferences of related groups, where the functions of one operator may be checked with those of others, making certain that nothing is being neglected or overdeveloped.

In inaugurating a management installation or revising one, the engineer is apt to overdo the mechanisms with an undue burden of overhead of money, time, and energy. This is allowable and may be valuable during the installation period, in order to make certain that everything is introduced which might be of service and that it receives a fair trial. Thereafter, the constant job is to simplify. It is essential that no item necessary for productive or emergency use be eliminated. Once this provision is made, the simpler the procedure, the better and the more effective.

In the pioneer plants, every technique of management was developed to its limit; job analyses, instruction sheets, forms of all descriptions. This task completed, the data were carefully filed for ready reference, while the actual working techniques were made as simple as was feasible. Even that phase was far more detailed than is necessary today, because the plants were used as object lessons by so many people. In those days, it was necessary to demonstrate methods as well as results of management. Today we demonstrate and measure results, checking the methods by the quality of the product and of the industrial relations.

QUESTIONS TO BE ASKED

Within the scope of this paper, it is not possible to consider in sequence the practical problems of management and their solutions. Only the method of approach can be outlined. In the completely developed scheme, satisfactory answers to the following questions should be developed:

1 Is the industrial project based on a philosophy which is positive, aggressive, and optimistic?

2 Does the personnel subscribe to ethical standards as high as those which the professions hold?

3 Are the economic theories followed those of an economy of plenty, i.e., does the project aim to be economically as well as financially sound; does it furnish the personnel adequate returns for the effort expended and the public adequate returns for its money?

4 Is the human element of prime importance in any work done and are universal likenesses and individual differences between people adequately considered?

5 Are the techniques of management which govern the most effective use of money, time, and energy being used? These are outlined in the standard textbooks and are kept up to date in the scientific and technical papers in the immediate and the related fields, especially in industrial engineering and industrial psychology, which are becoming more and more closely related.

6 Is an adequate cost system so completely installed that it is possible to know the results of changes not only after they take place but while they are being planned?

7 Is management looked upon as an educational process available to everyone continuously and under progressive leadership?

If the answers to all of these questions are satisfactory, there need be no fear as to the value and the endurance of the project. If doubt exists as to the real value of some of the questions, which may seem impractical and far removed from shop procedure, it is but necessary to study successes and failures of yesterday and today in industry to find that each and every check is necessary.

INSTALLATION SEQUENCE

As a concrete example of the installation sequence of one technique of management, that is, motion study in a small plant, the following data are presented:

1 The executive responsible for management decided that motion study was a sound management technique.

2 He checked on the market and found that reduction of the cost of the product was necessary in order to make the selling price competitive. A graph demonstrating this fact and the necessity of motion study was presented to the entire organization.

(*Continued on page 604*)

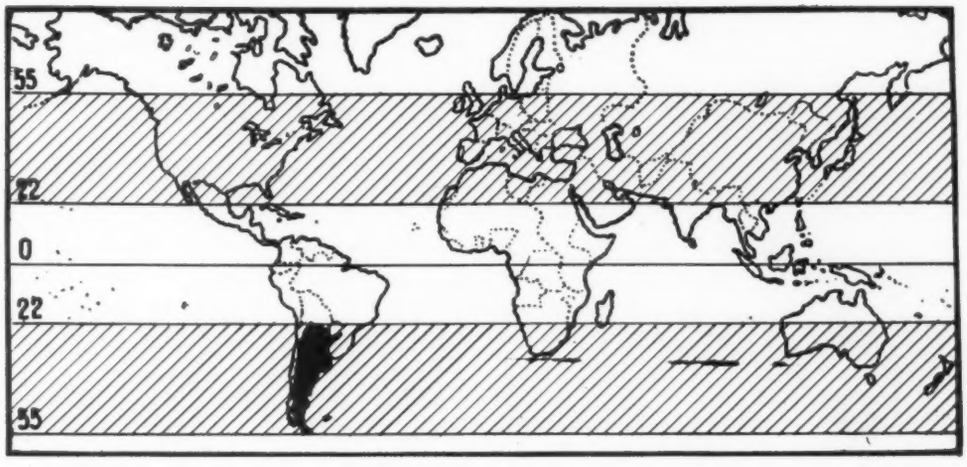

FIG. 1 GEOGRAPHICAL POSITION OF ARGENTINA IN THE WORLD
(From "Argentina Económica," by Garcia-Mata and Llorens, Buenos Aires, 1939.)

Some TECHNICAL *and* ECONOMIC ASPECTS *of the* ARGENTINE

By RODOLFO E. BALLESTER

DIRECTOR OF IRRIGATION OF ARGENTINA

THE DECISION of The American Society of Mechanical Engineers to designate as the 1939 Calvin W. Rice Lecturer an Argentine engineer, in his character of Director of Irrigation, was heartily welcomed by the government of his country, to whom it seemed particularly appropriate that he would deliver the lecture on the western coast of the United States in the marvelous State of California, pioneer in, and setter of standards for, hydraulic projects.

The memory of the great Secretary that Rice was, remains thus honored, and his purpose of encouraging international relations among engineers is thus fulfilled. A better mutual knowledge must be the basis of a good relationship, and since you—North Americans, who are the prototype of the enterprising man whose aim is the welfare of your nation—have little time to engage your thoughts in affairs that lie beyond your frontiers, and since with us—Argentines—sometimes the same thing happens, I have thought it suitable to give you a brief summary of the Argentine in so far as its economic and technical aspects are concerned, adding some thoughts about our engineering and yours as well.

Before leaving Buenos Aires, one of my best American friends told me: "You Argentines are very formal in your speeches. If you have to deliver a lecture in the United States, try to start it with some joke; it aids in holding the attention of your audience." Desirous of following this advice, I filled one of my bags with a lot of Argentine jokes. Arriving at New York I made my customs declaration and to my surprise the customhouse official, in a very courteous manner, informed me that my bag would be held. "Why so? I shall pay the duties," I argued. He replied that it was impossible to introduce jokes because they were not listed on the tariff schedules!

I am sorry that we, being good neighbors, cannot enjoy together one of the best products of my country.

Calvin W. Rice Memorial Lecture delivered at the Semi-Annual Meeting, San Francisco, Calif., July 13, 1939, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

THE ARGENTINE: GEOGRAPHICAL ASPECT

The general geographic aspect of Argentina may be easily understood if we remember that the country extends from latitude 22 south to latitude 55 south, with all the climates similar to those existing in North America from the Peninsula of Florida to the south of Hudson Bay in Canada, and to those of all the great European countries except Sweden and Norway. (See Fig. 1.[1]) Argentina covers an area of 1,080,000 square miles. The United States is nearly three times larger than Argentina.

The Cordillera of the Andes forms the western boundary of Argentina and includes the highest peak in America, the Aconcagua (7030 m or 23,000 ft) over which three air lines join Buenos Aires and Santiago de Chile. Parallel ridges of mountains in the provinces of Jujuy, Salta, Tucumán, Catamarca, Córdoba, La Rioja, and San Luis complete the principal orographic system.

The hydrographic system comprises rivers from the huge Paraná with 16,300 cu m per sec (580,000 cfs) of average flow, down to the small rivers of the barren zone which are sometimes dry for several months at a stretch. The different hydrographic basins have been subject to a classification made by the corresponding service of the Department of Irrigation (as shown in Fig. 2) and their study is given greater importance every day both by the federal and provincial governments.

[1] From "Argentina Económica," by Garcia-Mata and Llorens, Buenos Aires, 1939.

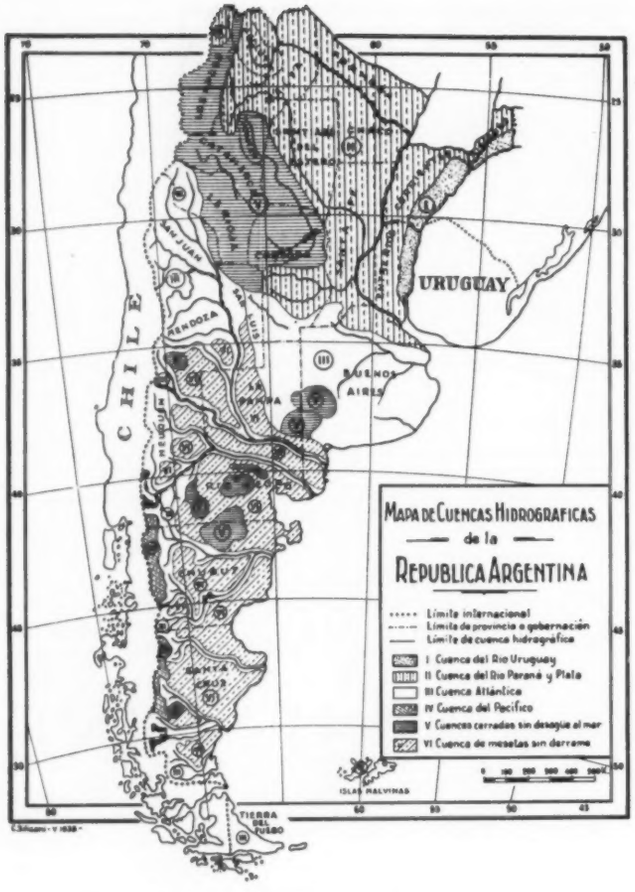

FIG. 2 HYDROGRAPHIC BASINS OF ARGENTINA
(From Department of Irrigation of Argentina.)

Because of great climatic and relief variations, soils offer very different characteristics as regards their use. Four distinct regions have been established[2] (Fig. 3):

(*a*) The subtropical zone of the North, where we find extensive growing of sugar cane, tobacco, and cotton, and enormous forests of hardwood.

(*b*) The zone of the Andes, at the foot of the range and parallel ridges, including the arid and semiarid regions of the West, similar in position and character of exploitation to the West of the United States. Irrigation is indispensable there for agriculture.

(*c*) The pampas—a flat, most fertile area, of an extraordinarily benign climate. It is the richest part of the country as regards the harvesting of wheat, maize, linseed, oats, and barley and the rearing of cattle of all sorts.

(*d*) The Patagonia, mostly arid and principally devoted to sheepbreeding, with transverse valleys that run from east to west, in which irrigated agriculture is to be found. Alongside the Andes there is a strip of land where numerous lakes and woods are scattered—the future site of great towns—and where the most renowned Argentine parks are to be found.

POPULATION AND ITS DISTRIBUTION

Amid the aforementioned surroundings 12,900,000 inhabitants are now living.

Colonized by the Spaniards through two conquering currents, one entering the River Plate and the other coming down from Alto Peru and Lima, the Argentine pronounced herself independent in 1810, immediately abolished slavery, and continued the development of the country with the help of the natives and of European immigrants. As a result of this evolution, the racial make-up is now as follows:[3]

Native Argentines of European descent, per cent....	77.4
Foreigners (mostly Europeans), per cent.....	19.5
Native Argentines with traces of Indian blood (and very seldom of colored), per cent.....	3.1
	100.0

Full Indians are very scarce, perhaps not even a hundred thousand, and the number of colored people is practically nil.

If the origin of the Argentine population offers a rather homogeneous index, nothing of the kind is true of its distribution throughout the country. The natural richness of the pampas has brought about an extraordinary concentration of population in them; hence there exists a certain lack of balance in the economic status of the country as a whole that we are constantly trying to remedy by a search for a greater functional unity. A numerical expression of this concept has been established by A. E. Bunge,[4] as follows:

If, taking Buenos Aires as a center, we draw two circles, one of 580 km (360 miles) and the other of 1000 km (620 miles), we divide the country into three zones (Fig. 4), and if we assign to zone I an index of 100 as to population, natural wealth, and production, zone II would have 15 as an index, and zone III only 9. The shape of this distribution caused Bunge to call the Argentine "a fanwise country."

RAILROADS AND HIGHWAYS

It is true that the lack of economic balance already referred to is closely associated with geographical and agrological factors, but, for all that, it is precisely in this condition that constructive efforts find their origin through which the unity of the nation can be assured. These efforts to insure national unity

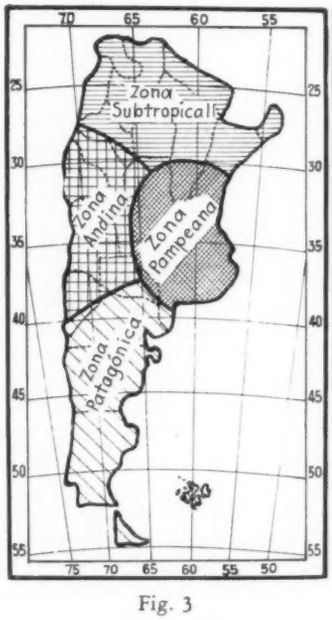

Fig. 3

Fig. 4

FIG. 3 AGRICULTURAL ZONES OF ARGENTINA
(From Garcia-Mata and Llorens, op. cit.)

FIG. 4 DISTRIBUTION OF ARGENTINE WEALTH IN THREE ZONES
(From A. E. Bunge, *Revista de Economia Argentina*, March, 1939, p. 71.)

[2] From "Argentina Economica," by Garcia-Mata and Llorens, Buenos Aires, 1939, p. 29.

[3] A. E. Bunge, *Revista de Economia Argentina*, February, 1939, pp. 35–37.

[4] Ibid., March, 1939, pp. 71–73.

started when railroads spread from the big river system to the farthest points, in other words from the cities of Buenos Aires and Rosario toward the interior, which may be compared to the westward expansion of the United States. Later came the completion of hydraulic projects and other public works, and, recently, in 1933, the building of a national highway system with funds supplied by gasoline and lubricating-oil taxes, carefully safeguarded against any direct or indirect diversion. Next year you will be able to cross from the Atlantic to the Pacific on a first-class highway; and, perhaps before five years are over, from the Tropic of Capricorn to the Strait of Magellan, we shall have a similar road extending more than four thousand kilometers.

On the 43,000 km of Argentine railroads, British initiative and capital have predominated, but in the realization of that vast highway-building plan, American experience has proved of incalculable value. Our engineers have learned extremely useful lessons in this country. You have assisted us with a splendid spirit of cordial cooperation, and we sometimes employ American engineers who collaborate with our organization. I must also add that 95 per cent of the nearly half million cars and trucks that run on our highway system have been bought from the United States, in addition to a great portion of the equipment necessary for the construction of our highways.

IRRIGATION

The majority of the agricultural and cattle-raising enterprises in Argentina are carried on without artificial irrigation; nevertheless, climatic and soil conditions render irrigation indispensable in many regions of the country. Our West and Northwest are arid; and if we are to gage their value, we should do so according to the number of cubic meters of water that can be used for agricultural purposes from the few natural streams in existence. The same kind of economic struggle that exists between your West and your East is found in the Argentine Republic. The federal government maintains in its Ministry of Public Works the Department of Irrigation which takes care of irrigation, drainage, and flood-control projects. Some provinces do the same within their boundaries. Works are carried on directly by the national government or in combination with the provinces. In some provinces these are really federal-aid-irrigation enterprises. A digression on our political system of government would not be amiss here: it is federal, following the example of the United States, with fourteen provinces or "states" and ten territories depending directly on the federal government. These territories, once their population and culture attain a certain degree of development, will become provinces.

Two thirds of the Argentine is arid or semiarid, and, generally speaking, irrigation is resorted to west of meridian 63 W of Greenwich, where the isohyets of annual rainfall are less than 500 mm (20 in.). Nonetheless, in the tropical zone rainfall ranges up to 800 or 1000 mm (32 to 40 in.), but as the summer rainy season is very short, irrigation is required in winter and spring, especially for sugar-cane and cotton growing.

The total area devoted to agriculture in Argentina is about 27,200,000 hectares (67,200,000 acres) of which 900,000 hectares (2,200,000 acres) are under irrigation, i.e., about 3.3 per cent. (The general distribution of the zones under irrigation and their relation to the total are shown graphically in Fig. 5.) If the irrigated area seems relatively small, with respect to the total (in the United States it is 4 per cent), its regional importance is extraordinary. If we suppressed irrigation in California (U. S. A.) or in Mendoza (Argentina), these states would be worth very little in their own Union or Republic.

I am not going to start an argument in favor of irrigation in the heart of California, but perhaps some figures might prove of

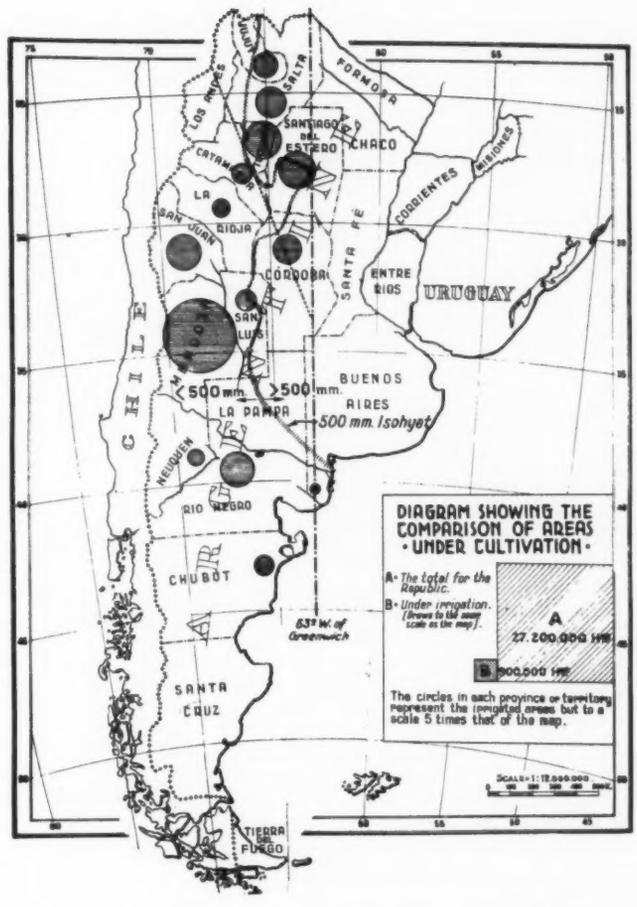

FIG. 5 DISTRIBUTION OF IRRIGATED AREAS IN ARGENTINA

interest. In a recently published paper[5] on irrigation in the Argentine Republic I point out that in the valley of Rio Negro (Argentina), where irrigation covers a system of 130,000 acres, each hectare (2.47 acres) gave the railways three metric tons of annual traffic. On the other hand, where agriculture was carried on without irrigation, it gave only 0.2 ton in the same period, i.e., one fifteenth as much. The same proportion is obtained when traffic per mile of rail in the valley is analyzed. We should remember that such a high proportion does not take into consideration the values per unit of weight of the products, which in irrigated zones are much higher than where irrigation is lacking.

The action of the federal government is directed specially toward the great water-conservation works which the financial and technical capacity of the provinces does not allow them to undertake. Six dams have already been built, three are under construction, and two or three more will be started next year. We have no Boulder Dam, no Grand Coulee, no Shasta dam, perhaps because our Latin idiosyncrasy leads us to extend to many things Virgil's advice on farming, "of admiring the big property and cultivating the small."

INDUSTRY AND COMMERCE

If we were to describe the Argentine in terms of one type of industry, we should say that it is essentially a country of "rural industry," very much developed, thanks to the exceptionally favorable climate and soil of the southern part of meridional America. The narrow wedge—1300 km (800

[5] "Some Technical and Economic Aspects of Irrigation in the Argentine," by R. E. Ballester, *Journal of the Buenos Aires Association of the Institution of Civil Engineers*, no. 8, Session 1938, Buenos Aires.

miles) wide, between the Atlantic and Pacific in the region of the pampas, covered with a thick layer of humus, with sufficient rainfall and natural grazing fields—allows all cultivation and cattle-raising in the open air the whole year round without the stocking of forage.

The cultivation of linseed and cereals, for whose harvest our farmers used to count on temporary immigration thirty years ago, has come to be almost wholly mechanized due to the introduction and adaptation of machinery, especially from the United States. On our farms you can find everything from plows to harvester threshers with the brands of International Harvester, Avery, and Allis-Chalmers, and forests of windmills manufactured in your eastern factories to pump the drinking water for our cattle.

The American engineer with his inventions has contributed unwittingly, maybe, to permit us to lower the cost of our basic production, thus enabling us to offer the world some of life's indispensables at a reasonable price.

Our farmer has raised and goes on raising his standard of living because the assistance of machines to agricultural production has lessened the number of men on the farm; and thus we have today, in the distribution of population, a rate of 26 per cent rural and 74 per cent urban population, in towns of more than a thousand inhabitants—figures which have caused the Argentine to be classified as a "rural country of urban population."[6] That is to say, the farmer cultivates his farm but lives in the nearest little town or city. Thus, it is not a low standard of living which permits us to produce at a low cost, but the climate, the soil, and the progressive character of the men who do not keep obstinately to tradition but look forward and accept the progress of civilization.

The importance of our rural industry can be gaged by the fact that it represents 95 per cent of our export trade, including agricultural products (59 per cent) and cattle products (36 per cent); the remaining 5 per cent represents "other products." The total value of exports was, as an average (1935–1938), 1734 million Argentine pesos per year.

I shall mention some other figures, but first I wish to comment on these values in terms of dollars. To adopt the prevailing exchange rate may lead to confusion, owing to the different purchasing power of the currency in each country. Here I have paid a dime for a streetcar or bus fare and something more for my breakfast. In the Argentine, with ten "centavos" of a peso, I pay my streetcar, bus, or subway fare. My breakfast costs me just as many *centavos* there as *cents* here. A skilled laborer earns one peso per hour in our towns; here he earns a dollar, but here he also pays his way in dollars. Of course we cannot apply this proportion to imported goods.

The volume of Argentine foreign trade suffers the inevitable variations of world commerce and it would be tiring to mention figures; but in the gross commercial activity of the country, its proportion is decreasing. Nowadays foreign trade represents only about 20 per cent of the total. The intense development of the manufacturing industries of the country during the last twenty years, i.e., after the World War, is the cause of this reduction. Before the War, for instance, it was usual that our wool (130,000 metric tons a year) should be exported dirty and come back transformed into material or clothes.

MANUFACTURING INDUSTRIES

The World War was a great lesson for us and an awakening of the industrial spirit of the country which urged us to transform the abundant and excellent raw materials that it produces. Many American firms that used to import their goods into the Argentine have gone to manufacture them there from local materials, and today, they have even come to export. To give an example, this is the case with the rubber industry.

The principal industry of Argentina is meat freezing and packing. In order of importance follow the textile industry, clothing, flour mills, and civil construction. The industrial census of 1935 gave 2,600,000 installed horsepower, of which 1,500,000 is in plants which generate electricity for sale.

Argentine industry will demand more and more motive power every day. Of the total 1,500,000 hp, only a little more than 3 per cent is hydraulic power. Hydroelectric power that could be easily developed does exist in the Argentine, but, unfortunately, it is too far away from the industrial centers already formed to make its transmission economical. Nearly all the hydroelectric plants built so far have been erected in connection with irrigation projects.

The fuels used for our industry are coal and oil. The former is wholly imported and it represents 3,000,000 tons per year. Of the latter, which represents 5,000,000 cu m (31,400,000 barrels), we import 2,300,000 cu m (14,400,000 bbl), while the remaining 2,700,000 cu m (17,000,000 bbl) is produced in the country itself.

Argentine oil production has doubled during the last ten years; yet we are striving to intensify it throughout the whole country which still has many unexplored regions. Besides its importance in assuring supplies to all industries, the cost of fuel to the country amounts to 8 per cent of its imports. Little more than half the Argentine oil is produced by a government department—Yacimientos Petroliferos Fiscales—and the remainder by private companies.

INDUSTRIAL MACHINERY

The Argentine has as yet no workable iron or coal beds that could serve as a foundation for those great industries. Our iron ore is the scrap iron whose exportation is forbidden. Accordingly, we must depend upon the purchase of foreign machinery for all our industry, as I have already said when referring to rural undertakings. *There* is the market for the products of the American mechanical engineer, but a market described by the representative of a great European factory, as the most competitive in the world. We Argentines, considering the prices and terms offered by the manufacturers, have grown accustomed not to pay cash, but we always pay on the established terms. It has been our government's pride and our people's sacrifice to honor all our foreign obligations even in the worst moments of world depression, and let the New York Exchange tell us how many countries have done this.

In the civil-construction field numerous Argentine companies carry on their activities, but I must also say that every large European firm has an affiliated company in Buenos Aires, incorporated according to the laws of the country. These firms handle a large volume of business, and at the same time find an outlet for the products—equipment and machinery—of their own countries. This is not the case with American companies, which have worked only temporarily signing important contracts—such as the one of the Buenos Aires subways—placing American equipment and rolling-stock but not staying in the market. Personally, I have never been able to find any other explanation for this, except the fact that your domestic market, being so important, you are not interested in contracts outside of your country.

UNEMPLOYMENT

The problem of unemployment, which assumes tragic characters in many industrial countries, has never become a serious question in Argentina. The first census of 1932, while depression was at its worst, showed 334,000 persons out of work. In 1936 the number had gone down to 45,000, i.e., only 3.5 per

[6] A. E. Bunge, *Revista de Economia Argentina*, March, 1939, pp. 71–73.

thousand of the entire population of the country. The government has never found itself obliged to take exceptional measures in its economic legislation to meet this situation.

CULTURE

The improvement of the cultural standing of the country by means of education is a fundamental function of the Argentine national government; preeminent attention is always devoted to it.

We endeavor to spread primary education even as far as the most distant districts of the country. Today there are more than 12,000 schools with 62,000 teachers. The words of one of our statesmen, uttered ten years ago, that the Argentine has more teachers than soldiers, are still true, and may Providence always so order it that the peace of the world will allow us to maintain this ratio.

High-school education is well spread as well, with 500 schools and 12,000 teachers.

Argentine college education is a function of the central government, with its universities of Buenos Aires, Cordoba, La Plata, Litoral, and Tucumán. This year a new one, the University of Cuyo, has been founded. Unfortunately, we have neither your magnificent colleges, nor perhaps the spirit of intense study that is their soul, the vision of your men who use their money to enhance the welfare of the country, generously bestowing it upon the universities. Only one or two of our public-utility corporations have been farseeing enough to pay for the cost of some special courses on subjects of their own interest.

There are 4000 students in the different schools of engineering of our universities. Opinion is spreading at this moment, and I think it justified, that we are facing the problem of an excessive number of graduates.

Professional teaching, on account of place and means, has an extended scientific basis, but its practical and specialized applications are reduced. Within the fundamental divisions of civil, mechanical, electrical, and mining engineering, we have not yet tended—and I think rightly—toward a very well-marked specialization, because the state of development of the country does not allow it. We have rather preferred a solid scientific foundation which will enable the graduate to begin his career without the fear of being confronted with the unknown. In the University of Buenos Aires, your degree of mechanical engineer corresponds to ours of industrial engineer. Because of the reasons already mentioned, we do not manufacture machines but use machines made in other countries to develop our industries and we must train our engineers to use these machines, to understand them, and even to modify them.

Many reasons have led us to establish a greater scientific contact with Europe than with the United States. Our college undergraduates read French and Italian fluently. The study of English has progressed extraordinarily in the last ten years, mainly due to the efforts of two private institutions: the Instituto Cultural Argentino Norte Americano and the Argentine Association of English Culture. Today, we find in Buenos Aires 8000 students of English attending the classes every hour of the day, profiting by the facilities provided by these institutions.

In Buenos Aires there are bookshops of all nationalities—French, Italian, German, English—but there is not a single one expressly devoted to the American book, nor do American books abound in our libraries either. To increase their number is *one* way to a greater intellectual intercourse that leads, as a natural consequence, to commercial relations. The red covers of A.S.M.E. Transactions and the blue ones of the *Journal of Applied Mechanics* began to appear only about three years ago in the University of Buenos Aires, though the first one was received by the "Sociedad Cientifica Argentina" (Argentine Scientific Society) in 1927. Of course, such publications could not be delivered to everybody, though it is always possible to analyze a mailing list conscientiously when people possess—as you have proved to—an ample spirit of cooperation.

Twice has the Argentine Center of Engineers been honored by the visit of a president of The Institution of Civil Engineers of England—Sir Brodie H. Henderson and Sir Richard Redmayne. Thanks to Sir Brodie our Center prides itself on its complete collection of Minutes of Proceedings, for he presented us with a few we lacked, and Sir Richard enlarged our list of publications with a modern magazine.

Certain American technical corporations spend enormous sums of money in "advertising" in the United States and they want to follow the same method in our country: the results are not always up to their expectations. Perhaps the surest way for intellectual cooperation would be to write their advertising copy along technical lines and send it to the libraries of universities and engineering societies. In fact, the analytical and reasoning spirit of the Argentine young man will not hesitate to adopt that which he finds best, no matter what its origin and even its cost may be.

The tendency to a greater intellectual intercourse does exist. Of our country I have cited the example of highway construction. As regards oil production the government department called Yacimientos Petroliferos Fiscales usually sends every year a few engineers to complete their training in the United States, and, perhaps, you know that our drilling and refining machinery was made in this very place. Scholarships are awarded for graduates to pursue the study of some science in your universities. *We* are to blame that their number is not larger so as to feel the influence of your more specialized education. We know, and—personally, *I* know—that your welcome has always been most cordial and generous.

Another way of cooperation: a little more Spanish—from you. Foreign languages open new fields, and hearts, and at once establish an easy understanding. With the poor English I am speaking, 90 per cent of this audience can follow me, I hope; but how many would understand my Spanish? Take out your slide rule and work it out. The knowledge of Spanish is not for you to read engineering books—the technical production in this language is limited—it is for you to read in the Latin soul of America the same noble ideals that have always inspired America's Anglo-Saxon soul.

ASSOCIATIONS OF ENGINEERS

The engineers of South America began and have already carried out a movement of mutual understanding. Eight countries—Argentina, Bolivia, Brazil, Chile, Colombia, Peru, Uruguay, and Venezuela—form the South American Union of Engineers (U.S.A.I.), originally constituted in 1935 by Argentina, Brazil, Chile, Peru, and Uruguay. In January, 1939, the first South American Congress of Engineering took place with great success in Santiago de Chile. It has fostered technical intercourse among the South American countries, and it is quite common today that every engineer who travels should ask for his U.S.A.I. credentials which will open for him the doors of the country he visits.

Argentine engineers have a central association which boasts about 2000 members—the "Centro Argentino de Ingenieros"—in which the different branches of the profession meet, though by far the most numerous are the civil engineers. There exist independent centers in the provinces, but all are brought together by another organization—The Argentine Union of Engineers. The word "Union" does not mean a labor association.

This clearly points out that our spirit of association has

spread far and wide. We may not have attained the high technical level of your four Founder Societies, but the social, cultural, and human levels are really high. I am firmly convinced that my country is ready for that greater collaboration and that great understanding of international relations between North and South American engineers that the Calvin W. Rice Lecture is designed to encourage.

It has been my aim to present to you a candid picture of my country. I am aware that my camera cannot be perfect; to improve it you must interpose some filters to take away any bits of personal color I may unwittingly have introduced. I hope that you will share with me the difficulties of my position as an Argentine, in having to prepare my own letter of introduction.

I think I should explain why my lecture has not been a technical one. For more than twenty years I have subscribed and have read North American technical publications, and day after day I have remarked upon the ever-increasing importance assigned by them to papers on human relations and I must follow this trend.

The engineer makes use of the forces and materials of Nature for the benefit of his fellow beings, he transforms matter and energy, often neglecting its effects, as his work has a result of great human value, which awakes new ambitions and leads to new ways of living. This extraordinary important consequence of his labor is often left aside for other men to mind, while he selfishly shuts himself up in his technical tasks.

I have a feeling that The American Society of Mechanical Engineers has clearly realized that this position has but a narrow scope; it has understood that an engineer should serve not only his profession but, above all, his country.

We all feel proud in Argentina that your Society should have looked to my country to offer the Calvin W. Rice Lectureship to one of our men, because we are certain it was done with the purpose of strengthening the understanding that the whole of America is a land where life is worth living.

Social Relationships and Industrial Unrest

(*Continued from page 580*)

The portions of the book which are devoted to the specific analysis of the foregoing phenomena comprise an important contribution to the understanding of industrial relations in the United States today. The author, however, is not content to leave his discussion there. Nearly one half of the book is devoted to a considerably more theoretical discussion of the wider implications of his analysis. Such chapter headings as "The Rise of Fashion and the Control of Consumer Demand," "A Note on the Relations Between Industry and Government," and "Socialism and Other Social Systems" indicate the wide horizons upon which the author's gaze is fixed.

These tentative and somewhat philosophical explorations make interesting reading, but this reviewer would have been content to have them omitted. The rest of the book provides material for considerable reflection, and until the reader has reflected and digested he is not prepared to evaluate these wider implications. Fortunately, the book is organized so that he can ignore them without destroying the unity of the main discussion. A little judicious sampling will make his choice an easy one.

Aside from this minor objection (which is, after all, just the plaintive bleat of a reviewer impatient with the almost universal compulsion authors have for exploring the most remote implications of their data) one cannot praise too highly Whitehead's convincing demonstration of the value of empirical studies in the field of industrial relations. When the three studies that provide the data for this book have been expanded by other workers to thirty or forty we will have the basis for something which is today but a dream of the more optimistic workers in this area—a science of human relations in industry. All credit to Professor Whitehead and to his co-workers for giving the dream some substance!

Management in the Small Plant

(*Continued from page 598*)

3 He indicated the advantages of motion study to (*a*) the stockholders, (*b*) the council of executives, (*c*) a key group in the plant which represented all management functions.

4 He checked through the employees manual to make sure that motion study would not upset established procedure, made a few revisions and additions, and issued a new edition.

This having all proceeded satisfactorily:

5 The principles and practices of motion study and the results were presented to all groups in the plant. No one offered objections to its installation, some were enthusiastic, some asked for time to decide when the work should start.

6 A competent member of the organization was trained to do the work.

While this was being done:

7 Every department of the plant was checked as to its adaptability and its ability to meet the demands of work standardization. This included (*a*) design; (*b*) manufacture, including purchasing, planning, production, inspection, maintenance, etc.; (*c*) cost accounting; (*d*) distribution and selling, including market studies.

8 The suggestion system was checked to make sure that it was adequate to furnish incentives.

9 Wages, hours, job analyses, job comparisons, and all the other data concerning industrial relations were checked.

10 The man being trained was ready.

11 The schedule of most effective installation was submitted to representatives of all divisions, including the foreman and workers and was accepted.

12 The installation of the motion study was started.

The time lags have not been indicated. They were expected, occurred, and were handled by waiting for that satisfied acceptance of the plan which is essential to stable industrial relations. The installation is progressing smoothly through its second year. It will be noted that the sequence of installation attempts to conform to an adequate educational process.

While this is but one concrete illustration it covers techniques applicable to a diversity of cases. In many respects, it is typical and exemplifies the flexibility of management techniques, the importance of the human element and the interest developed in the problems in small plants.

CONCLUSION

In the history of management development, which as yet is so brief, the small industrial project seems to be gaining in importance. What the future holds for it cannot be predicted with certainty. In addition to all other values, small industries can justify their existence in the fact that they are of such size and nature that careful observation of their functions can be readily maintained. Not only for those engaged in such projects but for everyone in the management field they present an interesting and a stimulating problem.

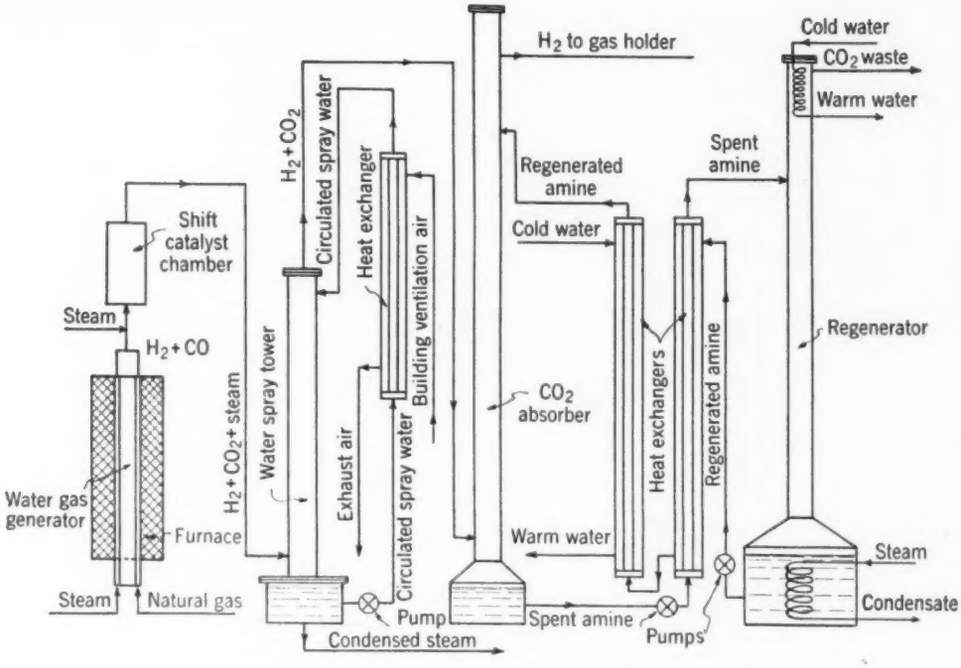

FIG. 1 SCHEMATIC FLOW DIAGRAM OF HYDROGEN-PRODUCTION UNIT

COAL HYDROGENATION

U. S. Bureau of Mines Experimental Plant

BY H. H. STORCH[1] AND A. C. FIELDNER[2]

UNITED STATES BUREAU OF MINES

THE essential chemical difference between bituminous coal and petroleum is that the carbon-to-hydrogen atomic ratio is about 1.2 for the former and about 0.6 for the latter. It is therefore apparent that if sufficient additional hydrogen atoms were combined with the coal, that is, if the number of hydrogen atoms in bituminous coal were approximately doubled, a material very similar to petroleum should be obtained. Dr. F. Bergius in 1913 discovered that it is possible to add hydrogen to coal at pressures of about 200 atm of hydrogen and at temperatures of about 450 C. Under these conditions all of the oxygen in the coal was hydrogenated to form water, most of the nitrogen to form ammonia, most of the sulphur to form hydrogen sulphide, and sufficient additional hydrogen atoms were chemically combined with the coal substance to produce a liquid very similar to petroleum. Subsequently the I. G. Farbenindustrie A.-G. discovered contact catalysts that increased the speed of the addition of hydrogen to the coal.

The nature of the catalysts employed in coal hydrogenation has been the subject of numerous patents. The presence of appreciable quantities of sulphur compounds and organic substances of high boiling points makes impractical the use of well-known active hydrogenation catalysts such as reduced nickel. A survey (1)[3] of the recent patent literature shows the outstanding importance of volatile chlorine compounds as catalysts in the primary liquefaction of coal by hydrogenation. A few amphoteric sulphides, namely, molybdenum, tungsten, and tin disulphides, are the most active of the solid catalysts employed. Stannous sulphide is reported to be particularly effective in the primary liquid phase of hydrogenation; molybdenum and tungsten disulphides are preferred for vapor-phase hydrogenation of tars or liquid primary coal-hydrogenation products.

As an example of the industrial application of catalysts in coal hydrogenation, a recent rather exceptionally informative patent (2) discloses the following: In the first or liquid-phase stage the coal is mixed with an equal quantity of a heavy oil (obtained from the hydrogenation of the coal itself) and 0.06 per cent tin oxalate plus 0.75 per cent of hydrochloric acid. This mixture is pumped along with hydrogen at 400 atm pressure through a preheater where the temperature is raised to 450 C, and then through three converters in series. The function of the converters is to provide "soaking" space during the 2 hr time of contact. In the second or vapor-phase stage, that fraction of the filtered product distilling between 250 and

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Contribution from the Central Experiment Station, Bureau of Mines, Pittsburgh, Pa. Published by permission of the Director, Bureau of Mines, United States Department of the Interior.

Contributed by the Fuels Division and presented at a meeting, Chicago, Ill., Oct. 13–15, 1938, under the joint auspices of the Fuels Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the Coal Division of the American Institute of Mining and Metallurgical Engineers.

[3] Numbers in parentheses refer to the Bibliography.

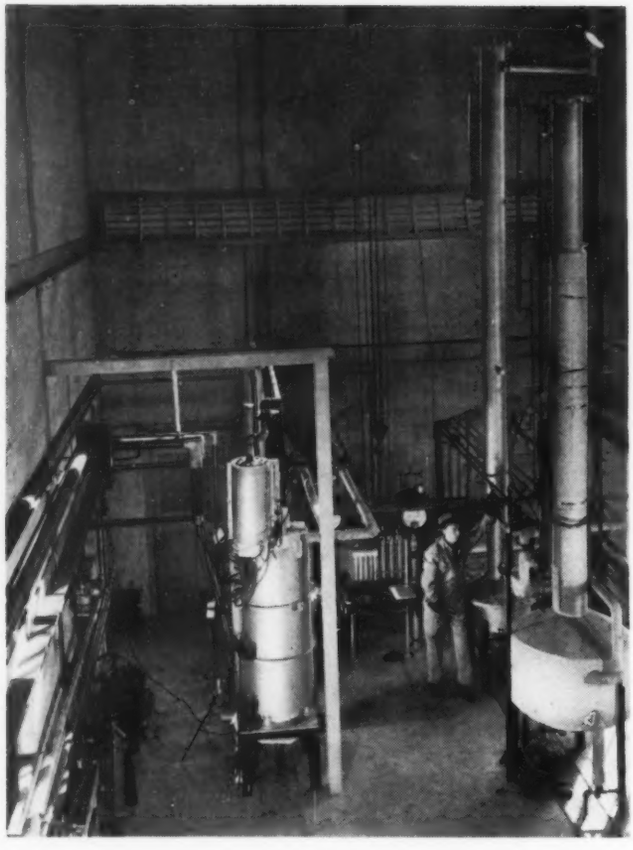

FIG. 2 HYDROGEN-PRODUCTION PLANT

350 C is mixed with hydrogen at 300 atm pressure and conducted at from 350 to 400 C, over a fixed tungsten-disulphide catalyst. The time of contact in this stage is about 1 min (for the vapor). The product of this stage is virtually free from oxygen, nitrogen, and sulphur. It is then passed along with hydrogen at 370 C and atmospheric pressure over a catalyst consisting of a mixture of molybdenum and cobalt sulphides deposited on active charcoal. This step removes the last traces of oxygen, nitrogen, and sulphur, and adds hydrogen to some of the unsaturated hydrocarbons. After this step the product is cooled and the wax that separates is filtered off. In the last stage the filtrate of the third stage is subjected to destructive hydrogenation at 530 C, with a catalyst consisting of a mixture of molybdenum, zinc, and magnesium oxides. The final product consists mainly of aromatic hydrocarbons such as benzene, toluene, and xylene.

The production of gasoline from coal by hydrogenation is now being practiced on a large scale in Germany, Great Britain, Japan, France, and Italy. Germany, with its huge plants at Leuna, Ludwigshaven, Gelsenkirchen, Bolen, and Magdeburg, is producing about 900,000 tons of gasoline per year from coal by reaction with hydrogen. Great Britain has a large plant at Billingham erected by the Imperial Chemical Industries. This plant produces about 150,000 tons of gasoline per year by the hydrogenation of coal. Similar albeit smaller plants are in operation in Japan, France, and Italy.

The United States has large deposits of both petroleum and coal. Although expert estimates differ concerning the life of our oil reserves, there is little doubt but that they are much smaller than our coal reserves and that at some future time the conversion of coal into gasoline will be an essential part of our industrial civilization. Because the chemical-engineering problems involved in coal liquefaction are difficult to solve with both technical and economic satisfaction, and in order to obtain information regarding the amenability of the various types of United States coals to hydrogenation for the production of liquid fuels, the Bureau of Mines considered it desirable to erect a small experimental plant.

HYDROGEN PRODUCTION

The coal-hydrogenation plant may, for convenience of description, be divided into two parts, namely, the hydrogen-production plant and the coal-liquefaction plant. A flow diagram of the former is given in Fig. 1.

Pittsburgh natural gas containing about 90 per cent CH_4, 8 per cent C_2H_6, 0.5 per cent higher hydrocarbons, and 1.5 per cent N_2 is mixed with about 1.5 times its volume of steam. This mixture enters the water-gas generator where the temperature is from 900 to 1050 C (1650 to 1920 F). The following reactions occur

$$CH_4 + H_2O \longrightarrow CO + 3\ H_2$$

$$C_2H_6 + 2\ H_2O \longrightarrow 2\ CO + 5\ H_2$$

The water-gas generator consists of two concentric tubes of $^1/_4$-in. wall, 7 and $4^1/_2$ in. OD, and 60 in. long, made of high-chromium-nickel alloy (25 per cent chromium, 20 per cent nickel). The 1-in. annulus between these tubes is filled with pure-nickel stampings $^1/_4 \times {}^1/_8$ in., which serve as a catalyst for the reaction between the steam and natural gas. Owing to the highly endothermic character of the reactions it is necessary to have fairly rapid heat transfer. For this reason heat is supplied from two sources, namely, a 1.5-in. Glowbar unit in the center of the inner tube and a high-temperature resistance heater surrounding the outer tube. About 100 cu ft of natural gas and 150 cu ft of steam per hr are passed through the water-gas generator. The water gas produced contains about 75 per cent H_2, 21 per cent CO, 1 per cent CO_2, and 1 per cent of $N_2 + CH_4$.

Immediately after its exit from the generator, the water gas is mixed with sufficient steam to drop its temperature to about 300 C. The resulting mixture of gases is passed into the water-gas shift chamber. This consists of a 24-in. section of 6-in. steel pipe containing at its center a 2-in. copper rod. Attached to the latter are eight copper plates or vanes which divide the chamber into eight catalyst spaces. This arrangement permits rapid heat conduction and avoids excessive channeling of the water-gas–steam mixture. Rapid heat dissipation is necessary because the water-gas shift reaction is exothermic.

$$CO + H_2O \longrightarrow CO_2 + H_2 + 10\ \text{kg-cal}$$

A copper-cobalt catalyst, the preparation of which was recently described (3), is used for accelerating the water-gas reaction. Approximately five parts of steam are mixed with the water gas as it issues from the water-gas generator. The exact amount of steam added is determined by the desired temperature gradient in the column of copper-cobalt catalyst. This gradient is preferably kept below 50 C, that is, a catalyst temperature of from 300 to 350 C.

The catalyst is very sensitive to sulphur poisoning, but the sulphur content of Pittsburgh natural gas is apparently sufficiently low to make purification unnecessary. It is however essential to remove any oil fog or spray which may be introduced by the gas booster.

After passage through the copper-cobalt catalyst, the gas mixture contains less than 0.2 per cent CO, since the bulk of the original CO has been converted to CO_2. The excess of steam in the gases coming from the copper-cobalt catalyst is condensed by the use of a water spray. The water used for this spray is cooled in "airofin" heat exchangers, using the building-ventilation air (10,000 cu ft per min) as the cooling fluid.

The spray tower is 8 in. diam × 8 ft with a reservoir 24 in. diam × 12 in. attached to its base.

The removal of carbon dioxide is accomplished in an 8-in-diam × 17-ft tower packed with $^1/_4$-in. carbon Rashig rings, over which a 10 per cent tetramine solution is flowing. A 24-in-diam × 12-in. reservoir is attached to the base of this tower. Tetramine (4) is mainly a mixture of diethylenetriamine and triethylenetetramine. The amine solution is regenerated by boiling and fractionation in a column packed with $^1/_4$-in. carbon Rashig rings. The boiler is 36 in. diam × 24 in. and the column 8 in. diam × 13 ft.

The CO_2-free hydrogen is collected in a 500-cu ft gas holder. A view of the hydrogen-production plant is shown in Fig. 2. To the left is the water-gas generator with the water-gas shift chamber immediately above it. To the right in the foreground is the amine regenerator, and behind it the CO_2 absorption tower. Along the back wall of the plant is the amine heat exchanger and immediately in front of this are the flowmeters for measuring the rates of flow of gas, steam, amine, and water. The amine pumps are under the amine regenerator and CO_2 absorption towers. The water-spray tower is not visible, being immediately behind the water-gas generator.

The plant has a capacity of from 400 to 500 cu ft per hr of gas containing about 0.2 per cent CO, 1.5 per cent $N_2 + CH_4$, 0.1 per cent CO_2, 0.2 per cent O_2, and 98.0 per cent H_2. This hydrogen is compressed to about 1800 psi and stored in cylinders until used in the coal-hydrogenation plant. Before use the hydrogen is expanded into a gas holder from which it passes into a 100-cu ft vessel on its way to the compressor. The purpose of the capacity vessel is to allow from 10 to 15 min for the automatic oxygen-analysis apparatus to shut off the compressor before an explosive mixture is drawn into the compressor. The hydrogen-production plant has functioned satisfactorily during a total production of about 75,000 cu ft of hydrogen. Since the first paper about this plant (10) was written the quality of the hydrogen has been considerably improved, and 50,000 cu ft of hydrogen have been made.

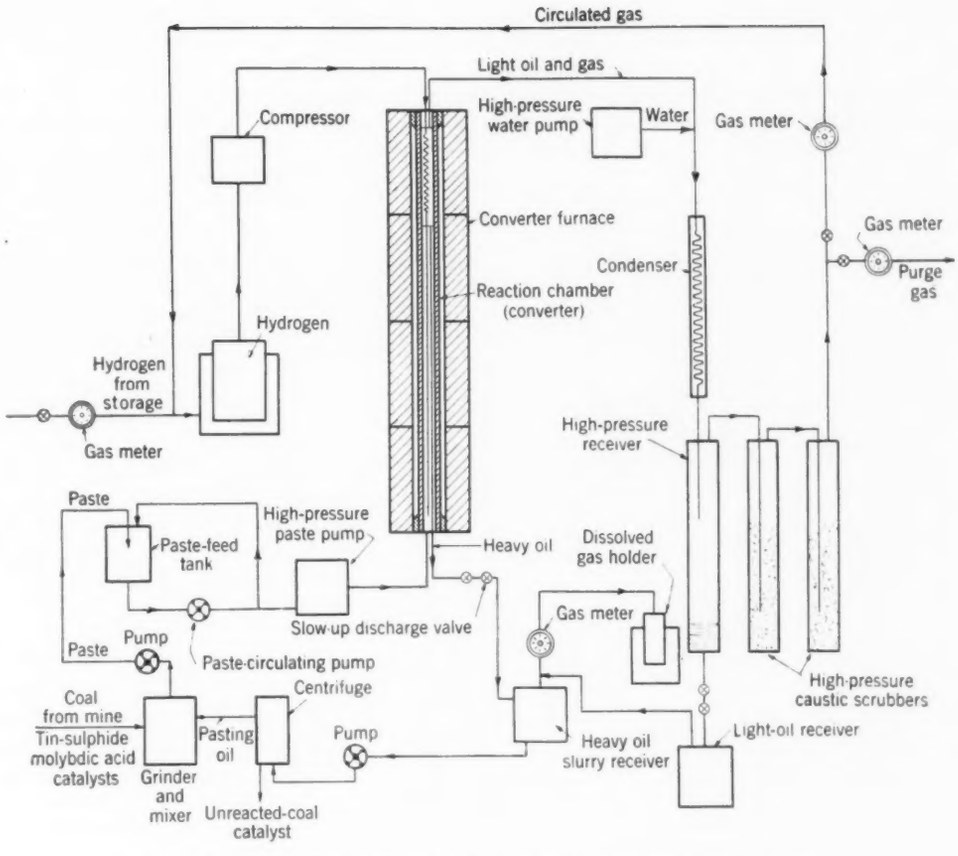

FIG. 3 SCHEMATIC FLOW DIAGRAM OF COAL-HYDROGENATION UNIT

COAL-LIQUEFACTION PLANT

A flow diagram of the coal-liquefaction plant is shown in Fig. 3. Coal, after being mixed with an equal weight of heavy oil and 0.25 per cent of tin sulphide, is ground in a ball mill until most of the solid particles pass through a 200-mesh sieve. The coal-oil paste is delivered under several pounds pressure by a gear-type oil pump to the high-pressure paste pump. The latter is a vertical-piston pump with steel-ball check valves and adjustable stroke. The gear-type pump draws the paste from an open container which is mounted on platform scales so that the weight of paste taken by the high-pressure pump can be determined at regular intervals of 15 minutes each.

Paste pumping is one of the most troublesome operations in the experimental plant. Mixtures of coal and tetrahydronaphthaline could not be pumped at all, because the check valves would clog rapidly with powdered coal. Mixtures of anthracene oil and coal could be pumped readily only after heating for several hours. The introduction of a gear-type oil pump to agitate the coal-oil paste by recirculation and to feed the paste under positive pressure to the high-pressure paste pump made the operation much smoother and eliminated the frequent loss of priming in the paste pump. It was found, however, that the gear-type pump would occasionally cause a gelling of the paste. This can be avoided by lowering the temperature of the paste and reducing the speed of the oil pump. With paste made from pasting oil characteristic of Bruceton coal, that is, the heavy oil obtained after several recirculations of oil to the head of the process, there is little tendency for the coal to settle out, and the paste can be pumped readily.

The paste is forced into the converter shown diagrammatically in the flow diagram of Fig. 3. The converter is a tube 5 in. OD and 3 in. ID, made of alloy steel, 18 per cent chromium, 8 per cent nickel. The converter closures are of the self-sealing type, shown in the assembly drawing of Fig. 4. The plug *A* is inserted, and then the monel sealing ring *D* is put in place. The collar *B* is screwed down until a light seal is obtained. Subsequently, the nut *C* is screwed down as far as it will go, thus pulling the plug *A* tightly against the undersurface of the monel ring *D*. The application of pressure to the inner surface of the plug *A* causes closer contact with the sealing ring, thus providing the self-sealing feature. It has been found that even with relatively loose assembly of this closure there is no leakage at 200 atm pressure. The fittings

which are used to connect the converter with the high-pressure paste pump and the hydrogen compressor are shown in Fig. 5. It is desirable that all of these fittings be made of the same alloy as the converter closure, in order to avoid difficulties due to differences in expansion coefficients. It will be noted that there are three openings in each of the two converter heads.

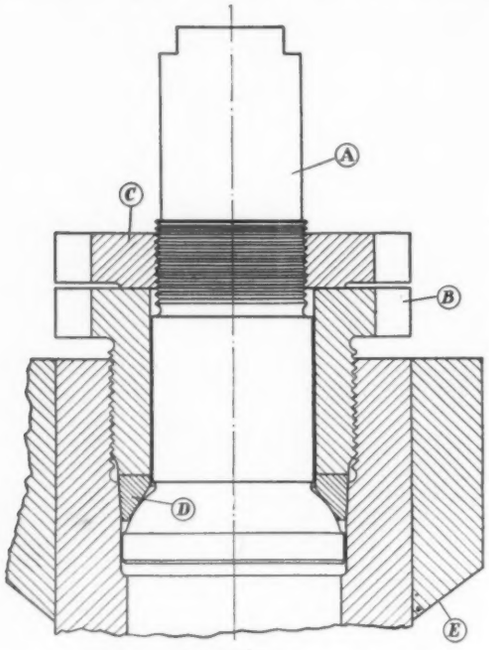

FIG. 4 SELF-SEALING TYPE OF CLOSURE USED FOR ENDS OF THE CONVERTER

In the top closure these openings are used for admission of cold hydrogen to the heat-exchange coil (see Fig. 3) inside the converter, for admitting a thermocouple well, and for discharge of the overhead-oil vapors and unreacted hydrogen gas.

The heat-exchange coil consists of 50 ft of $^3/_{16}$-in. OD × $^1/_8$-in. ID, 18 chromium, 8 nickel steel tubing wound in the shape of horizontal spirals or "pancakes" $2^3/_4$ in. in diameter. All of the spirals are contained in a 12-in. cylindrical can open at the bottom and connected at the top (closed end of the can) to one of the openings in the top converter closure. The lowest spiral of the coil is connected with a vertical tube that conducts the preheated hydrogen to the bottom of the converter, where it connects with a manifold for distributing the incoming hydrogen uniformly over the cross-sectional area of the converter. A steel-ball check valve is inserted immediately ahead of the hydrogen distribution manifold. This valve prevents the back surge through the heat-exchange coil of the slurry in the converter when any sudden changes in the pressure occur.

In the bottom closure the three openings serve to admit the paste, to connect with the standpipe inside the converter (see Fig. 3) for overflow of the heavy oil, and to provide an emergency hydrogen inlet (a steel-ball check valve is placed immediately over this opening) in case the heat-exchange coil should, owing to some mechanical failure, by-pass the hydrogen gas before it is conducted to the bottom of the converter.

The heat-exchange coil in the top section of the converter was designed to permit high hydrogen-recirculation rates without removal of an excessive amount of heat from the converter, and to reduce the attendant loss of pasting fluid by vaporization in the hydrogen stream. Recent experiments have indicated that high hydrogen-recirculation rates (that is, rates above about 100 cu ft per hr) are of no advantage in so far as speed of liquefaction is concerned. However, the heat-exchange coil has been retained because it acts to some extent as a high-pressure fractionating column as well as a heat conservator, and thus makes it possible to exercise precise control over the ratio of overhead to heavy oil.

Coal-oil paste (equal parts by weight) is pumped into the converter at the rate of from 5 to 10 lb per hr depending upon the reaction temperature which is usually between 425 and 450 C. The hydrogen is pumped in at the rate of from 100 to 200 cu ft per hr (measured at atmospheric pressure). The excess hydrogen above that absorbed by the coal is recirculated by the high-pressure recirculation pump, not shown in Fig. 3 but located just beyond the caustic scrubbers. Under the conditions used in this plant, the movement of the coal-oil paste and of hydrogen through the converter is that of streamline flow. When turbulent flow is employed, the reaction rate is considerably increased, as shown by the recent work of Morgan and Veryard (5). It is not yet certain, however, that turbulent-flow operation is feasible on a large scale.

The heavy oil overflows into the standpipe inside the converter and is discharged through a long coil of fine-bore tubing used in place of a valve to avoid severe valve erosion. Recently this discharge coil has been replaced by a valve developed in the laboratories and shown in Fig. 6. The wearing parts *A* and *B* are a loose-fitting rod and sleeve, respectively. The upward movement of the rod decreases the resistance to flow

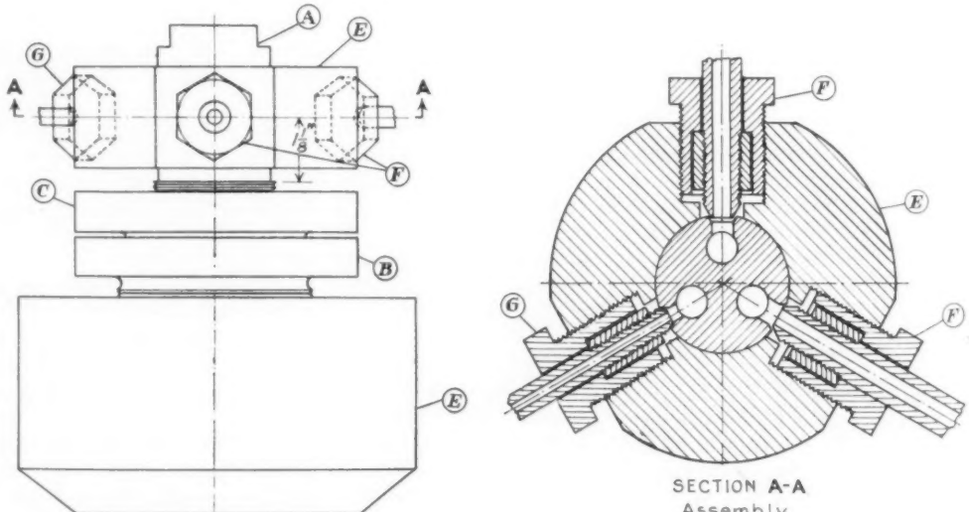

FIG. 5 CONNECTION FITTINGS ON CONVERTER CLOSURE

in the annulus between it and the sleeve. The discharge through the coil of narrow-bore tubing was never entirely satisfactory, and in almost every run the use of high-pressure valves placed before the coil was essential. The new discharge valve presents a large reserve area for erosion before replacement of the parts *A* and *B* is essential, and thus saves a large percentage of the machine-shop work on high-pressure valves. The use of a mixture of tungsten and tantalum carbides on the needle points and seats of the high-pressure valves reduces maintenance of these to a minimum.

The heavy-oil discharge consists of a slurry of a material resembling a primary coal tar with the ash of the coal and unreacted coal particles suspended in it. To facilitate discharge, all the valves and discharge pipes are heated by steam jackets to about 100 C. The slurry is diluted with about 30 per cent of its volume of a middle oil obtained by fractional distillation of the converter overhead oils and is then centrifuged. The centrifuged oil is used to provide the vehicle for producing the mixture of coal and oil at the head of the process. This oil contains from 15 to 20 per cent of benzene-insoluble material, of which from 3 to 6 per cent is inorganic (ash). All of this insoluble matter could be removed if the original slurry were diluted with about 10 times its volume of middle oil before being centrifuged. Such procedure was considered undesirable because the benzene-insoluble content of the heavy oil reaches a steady value after about eight regenerations of pasting oil.

The oil vapors carried through the top of the converter by the unreacted hydrogen gas consist of about 20 per cent of gasoline boiling below 200 C, and 80 per cent of a middle oil boiling up to 330 C. This overhead oil plus hydrogen is passed through a water-cooled condenser and then into the high-pressure receiver where separation takes place. The hydrogen gas passes

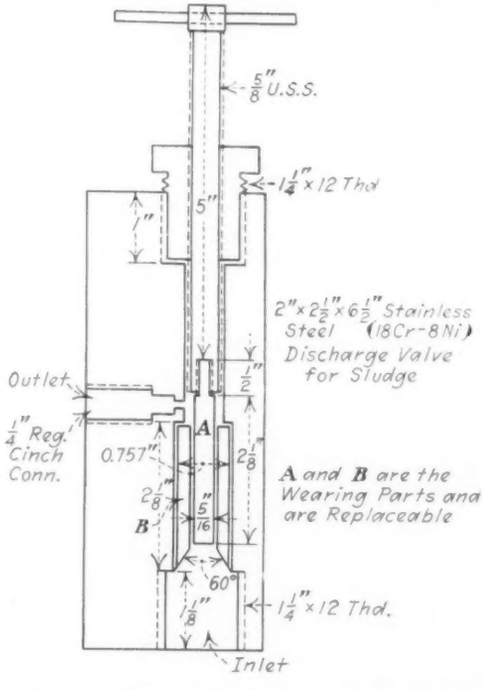

FIG. 6 HIGH-PRESSURE DISCHARGE VALVE FOR SLUDGE

on to the scrubber where, by passage over solid caustic soda, hydrogen sulphide is removed before the gas is admitted to the recirculation pump. The recirculation gas contains about 10 per cent of hydrocarbons, and the proportion of these is controlled by the rate of gas purging. It is planned to remove the hydrocarbons by scrubbing with an oil such as kerosene

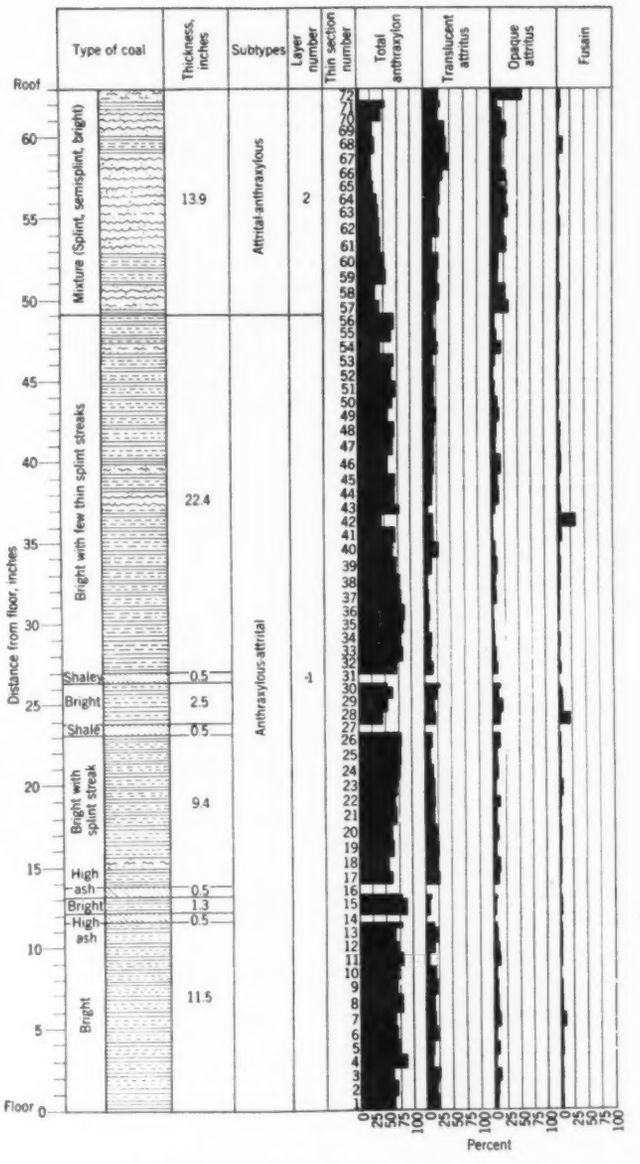

FIG. 7 TYPES OF COAL AND PERCENTAGES OF COMPONENTS IN PITTSBURGH BED, EXPERIMENTAL MINE OF THE BUREAU OF MINES, BRUCETON, PA.

or gas oil under pressure. The installation for this purpose will consist of a high-pressure oil pump, and oil-spray tower in which the gas at high pressure is equilibrated with oil, and a low-pressure gas separator in which the dissolved hydrocarbon gases will be separated from the oil.

HYDROGENATION OF PITTSBURGH SEAM COAL

The Pittsburgh bed is probably the most extensive and uni-

TABLE 1 PETROGRAPHIC ANALYSES OF THE PITTSBURGH BED AT FOUR DIFFERENT LOCATIONS

Components	Experimental mine, Allegheny County, Pa.	Pittsburgh Terminal No. 9 mine, Washington County, Pa.	Consolidation No. 63 mine, Marion County, W. Va.	Edenborn mine, Fayette County, Pa.
Anthraxylon.....	63	65	50	50
Translucent attritus	22	24	40	44
Opaque attritus....	12	7	7	2
Fusain.....	3	4	3	4

TABLE 2 DATA FOR MAXIMUM-YIELD CALCULATION

Constituent	Per cent of Bruceton coal, as determined by petrographic examination	Per cent organic insoluble residue from hydrogenation tests in small autoclave
Anthraxylon	63	1
Translucent attritus	22	1
Opaque attritus	12	25
Fusain	3	91

TABLE 3 DEPENDENCE OF OIL YIELD, GAS LOSS, AND RATIO OF OVERHEAD TO HEAVY OILS ON TEMPERATURE AND CONTACT TIME

All runs made at from 200 to 215 atm pressure

Run no.	Temperature, deg C	Paste-pumping rate, lb per hr	H_2 recirculation rate, cu ft per hr	Ratio, overhead to heavy oil	Viscosity, heavy-oil slurry, centistokes	Per cent on amf[a] coal + H_2: Oil yield	Per cent on amf[a] coal + H_2: Gas yield
			Temperature				
16–1	420	7.4	272	0.41	....	71.0	9.9
16–2	433	7.1	293	0.62	....	66.2	19.6
16–3	447	7.5	265	0.90	....	60.2	32.7
16–4	459	7.4	237	1.72	....	52.5	36.9
			Contact time				
19–2	440	3.8	229	1.26	287	62.7	29.5
19–3	440	7.3	228	0.58	787	68.8	21.9
19–6a	441	7.1	243	0.55	1808	67.7	20.5
19–8	440	7.3	238	0.46	1320	71.8	18.8
19–9	441	8.4	228	0.35	1190	72.0	16.8
4	445	8.5	250	0.78[b]	....	78.0	16.7
19–10	440	9.2	259	0.32	1690	73.3	15.3
19–1	440	10.0	243	0.39	1350	64.5	13.9
16–1	420	7.4	272	0.41	....	71.0	9.9
16–5	420	5.0	110	0.47	....	65.8	17.3

[a] amf = ash-and-moisture-free.
[b] No reflux column used.

TABLE 4 DISTILLATION RANGES AND SPECIFIC GRAVITIES OF OVERHEAD-OIL FRACTIONS

Per cent by volume, gravities at 15.6 C.

Run no.	Specific gravity as received	20 to 200 C: Per cent	20 to 200 C: Specific gravity	200 to 270 C: Per cent	200 to 270 C: Specific gravity	270 to 300 C: Per cent	270 to 300 C: Specific gravity	300 to 330 C: Per cent	300 to 330 C: Specific gravity	Over 330 C, per cent
16–1	0.967	22.3	0.883	45.0	0.972	16.0	0.998	12.0	1.024	4.7
16–2	0.975	20.3	0.883	37.5	0.973	18.2	0.999	14.5	1.023	9.5
16–3	0.968	22.5	0.866	33.8	0.970	16.0	0.998	14.7	1.023	13.0
16–4	0.974	24.5	0.878	36.0	0.973	15.3	1.004	11.5	1.033	12.7
19–2	0.962	22.0	0.877	40.3	0.966	18.2	0.993	15.0	1.013	4.5
19–3	0.955	25.0	0.875	40.5	0.967	16.0	0.992	11.3	1.009	7.9
19–6a	0.961	23.0	0.885	40.0	0.964	19.0	0.987	11.0	1.006	7.0
19–8	0.953	22.5	0.857	41.0	0.960	16.5	0.983	11.0	0.999	9.0
19–9	0.943	26.1	0.861	45.2	0.957	15.1	0.978	9.5	0.997	5.1
19–10	0.947	24.5	0.862	46.5	0.959	15.0	0.979	9.5	0.997	4.5
19–1	0.960	26.0	0.880	42.5	0.971	16.8	0.999	9.5	1.014	5.2
16–1	0.967	22.3	0.883	45.0	0.972	16.0	0.998	12.0	1.024	4.7
16–5	0.971	22.0	0.882	39.5	0.974	16.0	1.005	12.5	1.023	10.0

form coal bed in the United States. Its uniformity may be judged from Table 1 showing petrographic analyses made by G. C. Sprunk of the Central Experiment Station of the Bureau of Mines.

A more detailed petrographic survey of the coal from the Experimental Mine is presented in Fig. 7. In the assay work on this coal, a representative sample of the entire working face of the seam was used. Using the petrographic data given in Table 1, and the hydrogenation yields of each of the constituents as determined in a small autoclave test and shown in Table 2, the theoretical minimum nonliquefiable residue from Bruceton coal may be readily calculated and is 6.5 per cent.

Some of the results obtained for Bruceton coal are given in Table 3. The data on the effect of varying temperature show that the yields of benzene-soluble material decrease and the gas losses increase with increasing temperature. The limiting low temperature is determined by the time of contact desired and the viscosity of the heavy-oil slurry. From a practical point of view, the heavy-oil slurry of experiment 16–1 was as thick as could be conveniently discharged at 100 C, and hence if a lower temperature were desired a longer contact time would be essential.

It should also be noted that the ratio of overhead oil to heavy oil increases with increasing temperature. In operation of the experimental plant for assay purposes, it seemed desirable to adjust the ratio of overhead to heavy oil so that the amount of the latter was exactly equal to the weight of vehicle used to mix with the original coal. When a mixture of about 40 per cent amf (ash-and-moisture-free) coal and 56 per cent vehicle is used, the ratio of overhead to heavy oil, when a 70 per cent oil yield is obtained, should be 1/2. In addition to varying this ratio by changing the average reaction temperature, a very exact control may be exercised by regulating the amount of heat put into the top section of the converter, which in turn controls the amount of refluxing. In the later runs with Bruceton coal it was found essential to add to the heavy-oil slurry about 30 per cent of its weight of overhead oil. This was necessary to make up for handling and sampling losses, and to thin the tarry heavy-oil slurry so as to facilitate the centrifuging and subsequent pumping of the paste made with the centrifuged oil. In a large plant the handling losses would be virtually eliminated and the sampling losses would be negligible. It is therefore probable that the addition of from 10 to 15 per cent of middle oil to the heavy-oil slurry will suffice to regenerate the pasting oil. This addition changes the ratio of overhead to heavy oil necessary for complete regeneration of pasting oil from 0.5 to about 0.85.

The effect of increasing the contact time from 2 to 4 hr (decreasing paste-pumping rate from 7.5 to 3.8 lb per hr) at 440 C is decreased oil yields and increased gas losses. For contact times less than about 1.6 hr (9.2 lb paste per hr) at 440 C, this trend reverses itself, so that shorter contact times result in lower oil yields, although the gas losses are still decreasing. The exact location of the maximum yield cannot be stated with accuracy, but there can be no question concerning its existence.

No exact specifications can be given for optimum temperature and contact time. Thus there is a fairly wide range of temperature in which the contact time may be adjusted so as to give the same oil yield and the same viscosity of the heavy-oil slurry. This temperature range for Bruceton coal is approximately from 420 to 440 C; the corresponding contact-time range is from 2.75 to 1.75 hr. At temperatures higher than 440 C it is probable that a higher gas loss and lower oil yield would persist even at the limiting contact time for obtaining a sufficiently fluid heavy-oil slurry.

A number of runs were made at 440 C, 2 hr contact time, 3200 psi pressure, and varying hydrogen-recirculation rates from zero to 400 cu ft per hr (measured at atmospheric pressure). These runs showed that the effect, if any, of increased hydrogen recirculation was very small, that is, within the limits of reproducibility of the results. A similar conclusion has been reached by the British Fuel Research Laboratory (6).

It should be apparent from the foregoing description that

the coal-hydrogenation assay as developed by this laboratory consists essentially in determining the optimum conditions for the maximum yield of overhead oil consistent with the complete regeneration of the vehicle used in making a paste with the original coal. Under optimum conditions, Pittsburgh seam coal yields the following products:

Product	Per cent of ash-and-moisture-free coal plus hydrogen absorbed
Overhead oil	66 to 70
Hydrocarbon gases	20 to 25
Water, ammonia, hydrogen sulphide	3 to 6
Resistant carbonaceous residue	6 to 8

The distillation range and specific gravities of the overhead oils for the experiments listed in Table 3 are given in Table 4, and the proximate and ultimate analyses for runs 16–1 to 16–5 in Table 5.

TABLE 5 ANALYSIS OF OVERHEAD OILS DISTILLING BELOW 330 C

Proximate analysis, per cent by volume, gravities at 15.6 C

Run no.	Tar acids	Tar bases	Specific gravity, neutral oil	Per cent of neutral oil Olefins	Aromatics	Saturates
16–1	16.9	4.8	0.947	6.0	68.7	25.3
16–2	17.4	5.0	0.952	6.3	71.2	22.5
16–3	16.8	5.0	0.938	7.2	66.6	26.2
16–4	15.8	5.0	0.942	6.0	71.5	22.5
16–5	16.9	4.6	0.947	5.5	71.5	23.0

Ultimate analysis, per cent by weight

Run no.	Carbon	Hydrogen	Nitrogen	Oxygen	Sulphur	C/H
16–1	86.3	9.4	0.8	3.4	0.1	9.18
16–2	86.6	9.2	0.9	3.2	0.1	9.41
16–3	86.8	9.2	0.9	3.0	0.1	9.44
16–4	86.9	9.0	1.0	3.05	0.05	9.66
16–5	86.4	9.3	0.9	3.3	0.1	9.30
Pittsburgh seam coal (amf)	84.2	5.6	1.7	6.8	1.7	15.2

Table 4 shows that the gasoline content (20 to 200 C fraction) of the overhead oil is between 20 and 26 per cent. It increases somewhat with increasing reaction temperature but is not greatly affected by changes in contact time in the range from 1.5 to 2.0 hours. The fraction boiling between 200 and 270 C increases with decreasing temperature and decreasing contact time, and the reverse is true for the fraction boiling over 330 C.

Table 5 shows that about 17 per cent of the total oil yield is tar acids. This corresponds to 0.7 × 17, or about 12 per cent of the amf coal. This is about fifty times the amounts of tar acids obtained by coal carbonization. The neutral-oil fraction is from 75 to 80 per cent of the overhead oil, and about 70 per cent of the neutral oil is aromatic. A comparison of the ultimate analyses of Table 5 shows that about 50 per cent of the oxygen and nitrogen and almost all of the sulphur in the coal do not appear in the overhead-oil product and that the C/H ratio of the latter is about 9.4, as compared with 15.2 for the original coal.

SMALL-SCALE AUTOCLAVE EXPERIMENTS

In Fig. 8 is shown an assembly of a stainless-steel autoclave with a carriage for rotation and furnace for heating to reaction temperature. Two assemblies of this type are available. They are used for studying the fundamentals of coal hydrogenation in so far as they can be elucidated in a batch operation.

Studies of the efficiencies of various pure compounds as vehicles (7), of the ease of liquefaction by hydrogenation of the isolated constituents of coal such as anthraxylon (vitrain), attritus, fusain, and spores (8), and of the rate of removal of oxygen (9) from Bruceton coal have recently been made with this apparatus.

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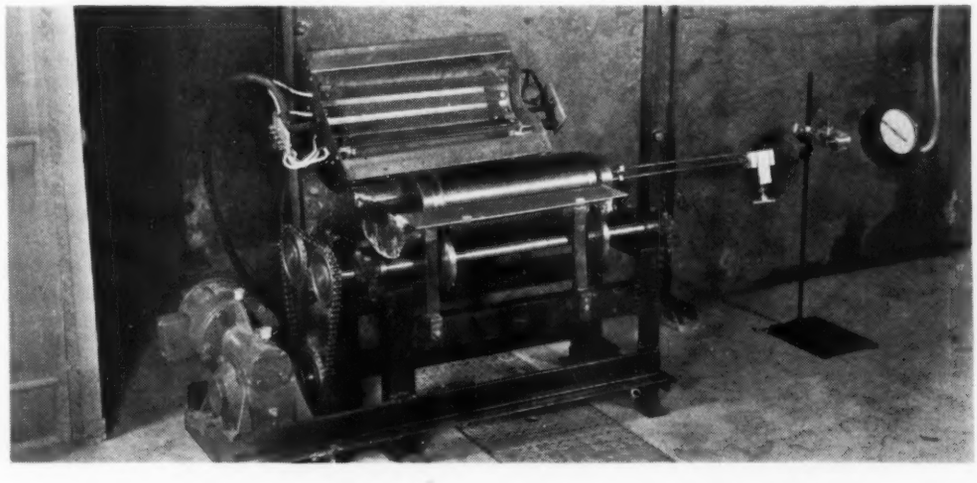


FIG. 8 AUTOCLAVE FOR COAL HYDROGENATION IN BATCH OPERATION

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Day by Day

BUSINESS activity, the downward trend of which was noted last month as having leveled off, turned upward in June. Altogether conditions at home and abroad have been sufficiently exciting, with the closing of some more far-eastern ports and discourtesies shown to the British in China by the Japanese; the tenseness over what was thought to be ready to happen in Danzig; and, in this country, the skirmish in Congress during the closing hours of the government's 1938–1939 fiscal year. As this is being written, all of these situations exhibit the uncertainties that are characteristic of the times and indicate that many changes of major importance are due to take place in the world before peace and economic security and well-defined forward progress of civilization can be reasonably well assured. The great question of what part the Soviet will play can only be conjectured; and individual conjectures, no matter how closely they may coincide with ultimate facts as they develop, must be based largely on the reasonable assumption that no part of the world as great in extent and as rich in resources as the U.S.S.R. can be ignored.

The exciting events centering around Washington appear to be of greater political than economic importance. For the first time since 1933 the Congress took a stand, ultimately unsuccessful, to recapture some of the emergency power it had turned over to the Administration. Drastically modified relief regulations were passed which already are the cause of protests on the part of labor-union leaders. The total relief appropriation of $1,798,000,000 represents a reduction of 45 per cent from the $2,539,805,000 appropriated last year. New proposals for stimulating employment via the spending-lending route were made by the President in a letter to Senator Byrnes. The proposed program, involving more than three billion dollars to be loaned at low interest rates for "self-liquidating" public and semipublic works, was pictured as not adding to the national debt, although the federal government, under the plan, would guarantee defaults.

Strikes, principally based on inter- and intra-union disputes, continued to harass the country, the latest important threat being directed at the automobile industry at a time when retooling for next year's models is under way.

Unemployment, according to figures of the National Industrial Conference board, declined 3 per cent in May and fell below the ten-million mark. The Conference Board also announced its estimates of 1938 individual incomes in the 48 states and the District of Columbia. The national income decline was said to have been 10 per cent from $69,400,000,000 in 1937 to $62,500,000,000 in 1938. As compared with 1929, in some southern states and in the District of Columbia, 1938 income exceeded 1929 income. Per-capita income for the entire country in 1938 amounted to $480; in 1937 it was $537. The highest per-capita figure, $1065, was for the District of Columbia, the lowest, $201, was for Mississippi.

Transatlantic air service was inaugurated by the round-trip flight to Europe with paying passengers of the *Dixie Clipper*. The 41-ton ship with a crew of 11 under the command of Capt. R. O. D. Sullivan with 22 pay passengers left Port Washington, L. I., at 3:12 p.m., Wednesday, June 28, and landed at Lisbon at 7:10 p.m. (3:10 p.m. New York time) on June 29. A stop of one hour and 44 minutes was made at Horta, the Azores. Her destination was Marseilles which was reached on Friday at 1:20 p.m. (9:20 a.m. New York time), 31 hours and 52 minutes of flying time. The return trip started at Marseilles, at 4:25 a.m. (New York time) Sunday, July 2, and, with stops at Lisbon and Horta, ended at Port Washington, July 4, 8:49 a.m., 34 hours and 27 minutes flying time. Mail service to Southampton, England, via Botwood, Newfoundland, and Foynes, Ireland, was also successfully inaugurated by the *Yankee Clipper*. On July 9 the *Yankee Clipper* with a pay-passenger list of 19, landed at Southampton, England, 27 hours and 20 minutes out from Port Washington, inaugurating transatlantic passenger service over the same northern route. At Elmira, N. Y., on June 28, the American altitude record for motorless planes was broken when a glider pilot reached an altitude of 13,400 ft.

The Engineers' Guild

On May 16, 1938, a group of British engineers inaugurated "The Engineers' Guild," the objects of which, as stated in that body's "new" constitution adopted on May 24, 1939, are "to promote and maintain the unity, public usefulness, honor, and interests of the Engineering Profession."

According to Bulletin No. 1 of the Guild, which reports a meeting on Feb. 20, 1939, membership had grown since the first meeting from a little over 30 to 200. As inaugurated, membership in the guild was restricted to members and associate members of the four British institutions of civil, mechanical, and electrical engineers, and the naval architects. In the new constitution such members are designated "ordinary members," and provision is made for honorary members and also for associates, who, in general terms, are graduates in engineering of a British university, graduates and students of the four institutions, and matriculated students of a British university who are pursuing a course leading to a degree in engineering. Only ordinary members are entitled to vote. An associate may not remain in that grade of membership for longer than a year after he becomes eligible for ordinary membership, nor after he attains the age of 35 years.

The business of the Guild is carried on by a General Council consisting of general, branch, and special representatives. General representatives are elected by ordinary members by means of a postal ballot and serve for three years; branch representatives are elected annually by the branches to serve for one year; and special representatives may be co-opted by the General Council to insure representation of particular interests not otherwise adequately represented.

A secretary, who also serves as secretary of the Engineers' Guild, is appointed by the General Council, which body also

elects annually its chairman from among its own members. The present secretary is V. B. Harley-Mason, care Midland Bank Ltd., 1 Central Buildings, Westminister, S.W. 1, London, England.

Branches may be organized in any district. At present no branches have been formed, but all members belong to the London and District branch with the privilege of transfer to other branches as soon as they are formed.

Provision is made for an annual general meeting to receive reports, but the General Council may call special meetings. Annual subscriptions are £1 1s for members and 10s 6d for associates. Safeguards against the use of Guild membership to imply a technical qualification conferred by the Guild are set up, and abbreviated designations of Guild membership may not be used professionally.

At the meeting of Feb. 20, 1939, already mentioned, it was pointed out that "the objects of the Guild did not clash with those of the Institutions. The potential membership of the Guild as at present constituted was some 30,000, and these should all support the Guild in order that the profession might be truly represented and exercise the beneficent influence in public affairs which was required from it. . . . ."

Among the problems discussed at this meeting were:

The difficulties arising from misappropriation of the title "engineer;" the control of the number and quality of entrants to the profession; the enforcement of discipline in matters of professional conduct; the inducing of engineers to come out of their professional shells and not to be discouraged by the greater difficulty of social as compared with technical questions; and the proper representation of the profession in public affairs.

It was also suggested that the Guild should collect statistics on remuneration as a guide to young engineers; that it should be prepared to advise on the quality of technical service required for a growing variety of purposes; that it should provide legal advice for its members in matters of employment and draft standard contracts embodying equitable terms and conditions of employment; that representation on joint industrial councils (Whitley Councils) of the profession as intermediate between employers and employees should be sought; that it should concern itself with the welfare of employees in the engineering trades and with the general prosperity of the engineering industry as well as with the interests of the profession.

Among other proposals as to policy and activities of the Guild, set forth in one of its early publications, are: Support of the benevolent funds of the Institutions by members of the Guild; support of the principle that work within the scope of the profession should be assigned only to engineers properly qualified to undertake it (the Guild is not yet ready to endorse registration of engineers, a subject that appears to the Council to require further investigation and careful consideration); consideration of the appointment of a committee on professional ethics; an endeavor to find means to be helpful to members in matters of employment; and also means to render corporate service to the public, to watch legislation and administration, and to initiate proposals for changes in the law whenever the profession can make useful contributions.

Air Conditioning With Caloride

INDUSTRIAL AND ENGINEERING CHEMISTRY

AIR CONDITIONING is the process of dehumidifying and cooling air in the summer and humidifying and heating it in the winter by one of several methods. One of the first methods, developed by Baekeland in 1903, was the drawing of the incoming air through a spray of water to eliminate dust, then cooling it by contact with refrigeration coils to remove the moisture, and finally reheating it to the desired temperature. In many installations today, especially in the smaller ones, this method of mechanical refrigeration is still used to cool and dehumidify the air, the only major change being in the utilization of fiber glass and other types of air filters instead of the water spray. The use of calcium chloride and other moisture adsorbents for the direct dehumidification of air for industrial purposes has been increased recently by the commercial preparation of new products and the reexamination of the older materials. Solid adsorbents such as silica gel and activated alumina are also recent developments.

350 F STEAM PRODUCED IN 15 SECONDS

(With a thermal efficiency of 90 per cent because the heating coils are directly immersed in water, a flash type of water heater no larger than an incandescent lamp can generate superheated steam up to 300 F from cold water in less than 15 seconds. The steam generator, made by Westinghouse Electric & Manufacturing Co., has an evaporating capacity up to 5.7 lb of water per hour, although only five ounces of water can be heated at one time. The chemical-resistant glass case is capable of withstanding an internal pressure of 25 lb per sq in., and will also withstand being transferred instantaneously from cold to boiling water, or vice versa, without cracking. Besides domestic and medical uses, the steam generator may be used for small-scale processes.)

Now, C. R. Downs, member A.S.M.E., has devised a new method of utilizing calcium chloride, which is described in several articles appearing in the February, 1939, and June, 1939, issues of *Industrial and Engineering Chemistry*. The moisture-absorbing material, called "Caloride," is a specially prepared hydrated calcium chloride in briquet form containing about 72 per cent of calcium chloride and a small amount of activated carbon for removing odors. In the articles, Mr. Downs discusses his experiments in air conditioning, production of the chemicals used, and the operation of two types of equipment designed for use with Caloride. Not using mechanical refrigeration in the accepted sense, one type for residential purposes is nonregenerative and the other type for industrial and large residential buildings is regenerative.

In the nonregenerative type of apparatus (Fig. 1), the raw air enters at 1 and is intimately mixed with Caloride solution which is discharged from nozzles 2 and broken up by impingement

targets 3. This method permits the use of nozzles with sufficiently large holes to prevent them from fouling. The solution absorbs moisture while in suspension in the air, whereby its temperature is increased, and then passes concurrently with the air into the finned-tube radiator 4. The solution spreads as thin films on the fins in contact with confluent turbulent streams of air and is cooled. Further heat is generated in the films but is removed as formed, and the air and solution emerge from the bottom of the radiator substantially in moisture equilibrium with each other, regardless of the moisture content of

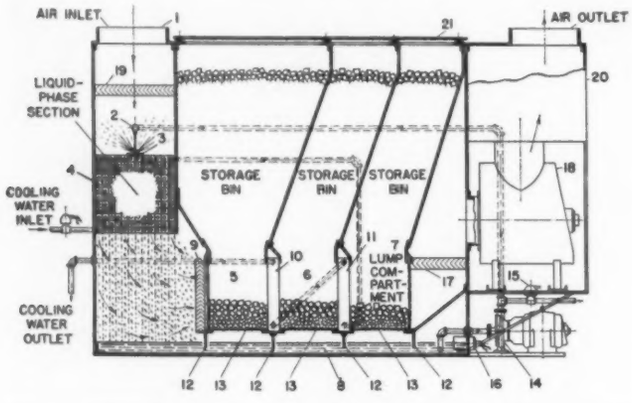


FIG. 1 VERTICAL SECTION OF NONREGENERATIVE AIR-CONDITIONING UNIT USING CALORIDE

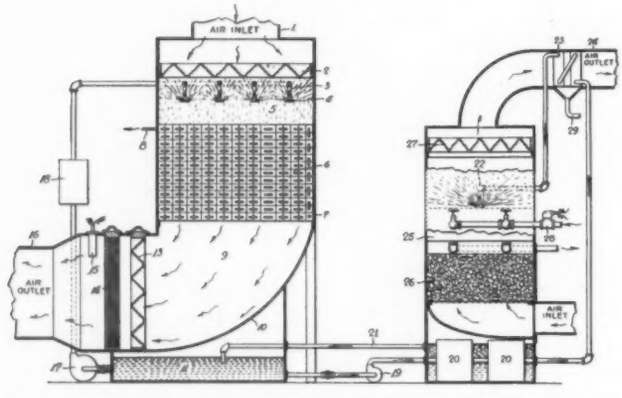


FIG. 2 VERTICAL SECTION OF ABSORBER AND CONCENTRATOR OF REGENERATIVE AIR-CONDITIONING UNIT USING CALORIDE

the raw air. The solution returns to reservoir 8 and the air continues through spray eliminator 9, compartments 5, 6, and 7, and finned-tube cooling coils 10 and 11.

Baffles 12, whose bottom edges are sealed by the solution in the reservoir, prevent the air from by-passing the compartment and cooling coils. These baffles are restrained from conducting heat away from lump-supporting screens 13 by suitable placement or heat-insulating provisions. The concentrated solution and the diluted solution draining from the liquid-phase section are mixed in the reservoir, and the mixture is sent back to nozzles 2 by pump 14. The discharge line from the pump is branched and contains a solenoid 15, which is opened and closed by the rise and fall of the float in level controller 16 to discharge excess solution to the sewer or to a storage tank. Cooling water is passed through the radiators in series or in parallel as desired. In winter, heated water is passed through the radiators instead of the cooling-water circuit used in summer, and if desired, solution or water may be sprayed into the air stream above or below radiator 4, or the solution in reservoir 8 may be replaced with water to humidify the warm air. Suitable float control means is provided for addition of make-up water to reservoir 8 as it is evaporated. A spray eliminator 17 may be placed before blower 18, a back-drift spray eliminator used at 19, and sound-absorbing material utilized in wind box 20 or in the inlet section above eliminator 19. Caloride is charged to the storage bins through hinged lid 21.

This particular nonregenerative apparatus was used in a one-family house during the summers of 1935, 1936, 1937, and 1938, and accurate records were kept of the use of water, power, and Caloride. From the results it appears that a unit capable of treating 750 cu ft of air per min will use, for an average summer, 2000 lb of Caloride, 17,000 gal of city water with a maximum temperature of about 75 F, and 110 kwhr of electrical power. Careful estimates show that the delivered cost of Caloride should not exceed $40 per ton, and under average conditions the total cost of air conditioning with Caloride will be in the neighborhood of $50. To this should be added the cost of operating an attic blower, which should not exceed $10 for the summer. In an apparatus 28 in. wide and 53 in. high, suitable for treating 1500 cu ft of air per min at low pressure, the liquid-phase section is 14 in. long and the solid-phase section 50 in. long. The latter section will hold a ton of loosely piled briquets of Caloride which is capable of absorbing 1800 lb of water.

In the regenerative air-conditioning unit shown in Fig. 2 the air entering the absorber at 1 may all be drawn from the outdoor atmosphere or from the conditioned space or from both sources. The operation is similar to that already described for the nonregenerative unit. The parts are the back-drift spray eliminator 2, nozzles 3, impingement targets 4 in space 5, finned-tube radiator 6 cooled by a coolant or water which enters at 7 and is discharged at 8. The hygroscopic liquid flowing from the fins at the bottom of the radiator 6 tends to coalesce into relatively large streams, and these coalesced streams separate in large part from the air in space 9. The liquid flows down the air-directing plate 10 and drains into the shallow reservoir 11. Any droplets of liquid still suspended in the air stream are separated by spray eliminators 13 and 14, and the cleaned air passes in contact with humidistat 15 on its way to air outlet 16.

The solution in reservoir 11 is discharged by pump 17 through strainer 18, if it is desired to remove suspended dirt, to spray nozzles 3. A second pump 19 draws solution from reservoir 11 and discharges it to the concentrator. For ordinary purposes about one sixth as much solution is pumped to the concentrator as is recirculated to the absorber, and both circuits flow continuously as long as the system is in operation. Various forms of heat exchangers have been used, but in this example an extended surface heat exchanger, 20, is immersed in a sump at the botton of the concentrator. This receives cold liquid from pump 19, which is preheated by the warmer liquid flowing down from the concentrating step. The prewarmed liquid then flows either directly to spray nozzles 22 or through a second heat exchanger 23 in duct 24. The preheated liquid is sprayed over and flows down through the extended surface radiator 25 where it is heated and partially concentrated, and then continues down through packed section 26 in which it is cooled by further evaporation, and thence into the sump for further cooling by heat exchanger 20. From the sump the concentrated liquid, at a temperature approaching that of the liquid discharged by pump 19, returns to reservoir 11 of the absorber. There it enriches the hygroscopic solution which, in turn, is pumped to sprays 3.

Radiator 25 may be heated by steam introduced through a solenoid or modulating valve 28 which is electrically or otherwise energized by humidistat 15 in the outlet duct from the absorber unit. When dehumidified air is to be discharged

through duct 16, humidistat 15 will open valve 28 when the relative humidity in duct 16 exceeds the set point of humidistat 15, and vice versa. Other parts are the spray eliminator 27 and the valve 29 whereby condensed water may be withdrawn.

Ultra-Low-Expansion Glass

SCIENCE NEWS LETTER

CHEMISTS of the Corning Glass Works have developed a new type of glass which can be heated cherry red and then plunged into ice water without danger of breaking, according to an article in *Science News Letter* for July 1, 1939. The secret of the new glass is its extremely low coefficient of expansion with temperature change.

While products of the new glass show virtually no change of dimensions when heated or cooled, because of its low expansion, it is quite a different story in the manufacture of the glass itself. Articles formed of it must be made larger than the desired final volume. Thus to get a nine-inch dish, a 12-inch dish is molded in the usual way but with the special glass formula to start with. Then by a series of steps, involving a final stage of leaching with dilute nitric acid, part of the structure of the glass is removed, leaving behind a "skeleton." By further heat-treatment this skeleton shrinks down to a volume which is 35 per cent smaller than the original size. At this stage the glass dish feels rough to the touch but not porous, although at this stage it is filled with submicroscopic air spaces.

By final heat-treatment the glass body shrinks just a bit more to a transparent, homogeneous state in which it is practically 96 per cent pure silica. To give an idea of contrast between the old and new glass, the Corning scientists quote the following comparative figures for expansions: Ordinary window glass 80, Pyrex glass 32, and the new glass 8.

Lead Attack on Exhaust Valves

S.A.E. WORLD AUTOMOTIVE ENGINEERING CONGRESS

EXHAUST-VALVE troubles consequent to the introduction of leaded fuel and high ratings, are, of course, well known to aeronautical engineers, as is also the relief obtained by the combination of sodium cooling and coating the face and head of the valve with stellite. For engine conditions prevalent at the moment, these innovations, generally speaking, have proved adequate, but the problem is bound to recur as performances, and hence valve temperatures, increase, according to a paper on "High-Output Aircraft Engines," by E. W. Hives and F. L. Smith, Rolls-Royce Ltd., Derby, England, presented at the New York session on May 25, 1939, of the S.A.E. World Automotive Engineering Congress. The authors have been engaged on a prolonged investigation into the cause and prevention of lead attack on exhaust valves. Apart from main-engine and laboratory tests upward of 4000 hours of single-cylinder engine running has been carried out in the course of the work.

During the course of the investigation many theories were established to account for the attack and were in turn discarded, and only one hypothesis has finally emerged which appears to account for all the facts. As far as Messrs. Hives and Smith know, no satisfactory explanation of this curious effect, which results in what looks like a bite taken out of the valve, has been published heretofore, and, therefore, it may be of interest to engineers to include a short account of the theory here.

Lead oxide is deposited on the head of the valve and fuses with the protective oxide skin. It now acts as an oxygen carrier and promotes further oxidation of the valve material. The oxide mixture creeps slowly, flowing as an extremely viscous liquid, to the edge of the valve where it is considerably heated by exhaust scour, and if the valve is seating perfectly or badly, it is broken up and blown out through the port, doing no further damage. If, however, the seat is just slightly faulty, the scale is able to adhere to the valve face and pitting occurs until eventually a slight gas leak takes place and a gutter is formed by the joining of the pits, which results in much higher local temperatures, and thus hastens the flow of scale from the head of the valve. This is the first stage of the attack.

If there is now an adequate deposit of lead oxide on the head of the valve the rise in temperature at the "blowby" can increase. The continuous supply of molten lead oxide from the head and adjacent pits in the roughened surface carries oxygen, obtained from a partial decomposition of the exhaust gas, to the steel which is doubly heated by the scouring and its own oxidation. A rapid "thermit" type of burning of the steel may now ensue, quickly leading to complete failure of the valve. In certain cases, the torch of exhaust gases, burning steel, and lead oxide, which was blown past the valve onto the aluminum wall of the exhaust port, has started a second violent "thermit" reaction which ultimately burned a hole through the port.

This "thermit" reaction can be simply demonstrated by dipping a piece of steel wire into lead oxide and then heating to red heat. If the wire is removed from the flame it will continue to burn in the region where lead oxide is present.

As a result of a prolonged series of tests, the authors' company standardized an exhaust valve cooled in the stem only and fully coated over the face and head with stellite. Fully sodium-cooled valves were tried but were discarded for various reasons. The reason for coating the head of the valve is to suppress the preignition, which results from the formation on the head of insulating lead oxide—iron-oxide mixture in the case of non-protected valves. The stellite-coated valve was not, however, completely satisfactory at higher power outputs because of cracking, lack of ductility, and a tendency on the part of the stellite to lead attack.

In view of these considerations, the authors sought a material which was more resistant to lead attack than stellite and more ductile. An alloy composed of 80 per cent nickel and 20 per cent chromium satisfied these conditions, and is even a suitable material for the construction of the body of the valve. A single-material valve is much to be desired, since it is free from relative thermal expansion effects and welding troubles.

Windowless Factory

THE world's first windowless factory, whose construction was halted in 1931 by the depression, was finally completed and put into operation at Fitchburg, Mass., by the Simonds Saw & Steel Co., on June 28, 1939. Everything from forging and heat-treating of steel to the sharpening and shipping of saws, machine knives, files, and other cutting tools, drafting, engineering, and office functions are carried out in the single 5-acre room, which has no partitions and is completely air conditioned. Operating two eight-hour shifts, five days a week, the plant assures each employee absolute uniformity of light at his job, regardless of the hour or weather conditions. More than fourteen thousand 100-watt fluorescent tubes provide a blanket of "cold" light over everything, shadows are eliminated, and the working plane receives from 20 to 25 ft-c of shadowless light from all directions.

The atmosphere inside the plant is kept clear, cool, and comfortable despite the presence of some 70 heat-treating furnaces, more than a 1000 individual motor-driven grinders, cutters,

and other machines which are in almost constant operation. The furnaces themselves are served by three underground flue-gas-exhaust systems with suction fans to exhaust gases directly outside from 63 different locations. While hundreds of emery wheels throw off sparks and dust in the grinding of saw teeth and knives, the air is kept clear of all such particles by 30 dust-removal units which filter the air and then recirculate it.

Large air-conditioning units in four building extensions adjoining the huge room circulate 400,000 cu ft of air per min through 3000 ft of overhead ducts to provide five complete air changes per hour. Automatic controls are set to maintain maximum comfort, which is provided in the summer by blowing the air through sprays of water which flows at 52 F from four artesian wells next to the plant. Air is also forced directly from these units to "man coolers" which moderate the temperature around the furnaces and drive the warm air up into the curtained ceiling areas above them, where all used air is exhausted through 42 roof ventilators.

FIG. 4 VIEW OF SIMONDS WINDOWLESS PLANT SHOWING END OF ONE OF THE EIGHT PRODUCTION LINES AND THE WALKWAY FOR VISITORS AT THE RIGHT

Four drop hammers, which forge the teeth for inserted-point saws, and similar equipment, are isolated by means of special foundations and shock-absorbing insulation, so that delicate precision-testing equipment in the metallurgical laboratory a few aisles away is not jarred. Walls of acoustic block and a cork-filled ceiling designed to absorb more than 90 per cent of the sound have muffled the noise created by the metal-working activity to a point which enables the telephone switchboard operator and office employees to work without difficulty.

Another interesting innovation in this factory is a quarter-mile protected walkway, four feet wide, from which visitors will be able to see the entire plant and its various operations. All machines are painted a bright yellow, all furnaces and benches aluminum, all steel columns, stairs, and walkways green, and the ceiling a light cream. The building contains 17,000 ft of underfloor power ducts, 38,000 ft of piping, 60,500 ft of galvanized-iron conduit, and more than 30 miles of wire and cable. These lines carry power, light, water, gas, steam, and air directly to machine and furnace locations by passing above the building trusses, down the columns, and under the floor, leaving the working area clear of such obstructions. Push-button controls are practically universal and central control of process piping is provided in the individual bays. Electric power to meet the plant's connected load of 6000 hp is provided chiefly by the local public-utility company and supplemented by the output of three Diesel engines operating at an old building near-by.

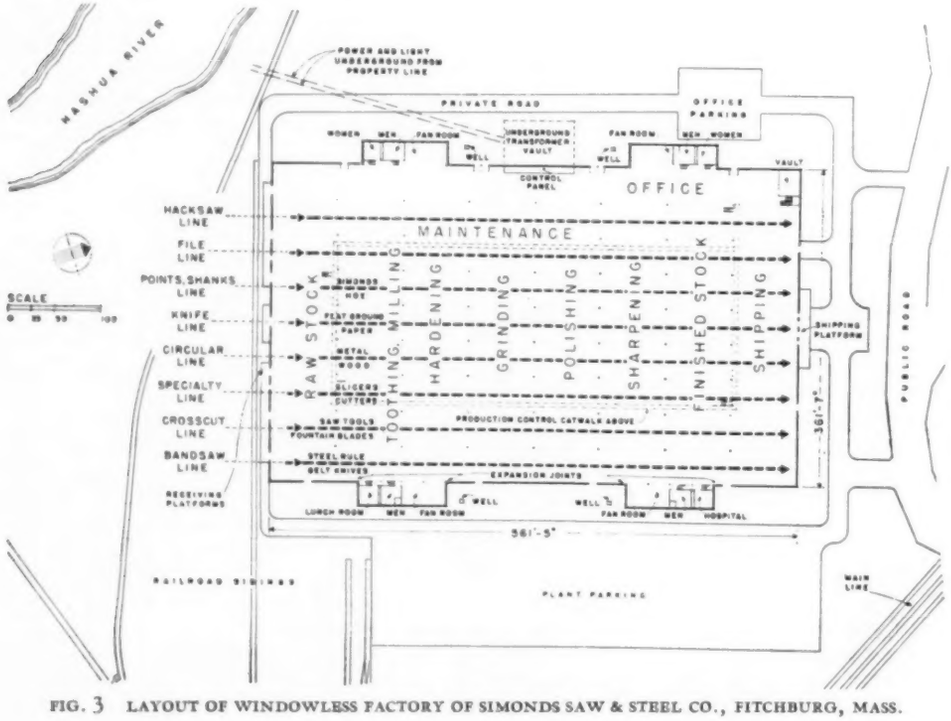


FIG. 3 LAYOUT OF WINDOWLESS FACTORY OF SIMONDS SAW & STEEL CO., FITCHBURG, MASS.

With bulkier products being handled along the side farthest from the offices, there are eight self-contained production lines under one roof, as shown in Fig. 3, each performing all the operations required to convert raw materials into finished products of a particular type under conditions conducive to efficiency and the required quality of product. Thus, each of the several thousand different types, sizes, and grades of saws, knives, and files made by the company moves in a straight line through the sequences of toothing, milling, hardening, grinding, polishing, and sharpening to finished stock bins and shipping platform.

Salvage in a Utility Company

EDISON ELECTRIC INSTITUTE BULLETIN

SALVAGING waste materials and equipment retired from service has been practiced by The Detroit Edison Company for the last ten years. Recently, according to an article by Kenneth C. Campbell in the *Edison Electric Institute Bulletin*, for February, 1939, a great improvement has been effected by gathering under one roof all salvage operations of a shop nature and all salvage material and equipment awaiting disposition. This was made possible by the use of an abandoned powerhouse. The turbines, boilers, auxiliaries, and miscellaneous equipment were cleared out and the building was cleaned, painted, and slightly altered. This in itself was a salvage achievement.

Many former methods have been improved in the last ten years and new lines of activities have been engaged in. The accounting setup now gives a breakdown of expenses by groups of operations so that any which develop an unprofitable trend can be quickly detected and corrected. A monthly "Salvage Report" is compiled to record the salvage division's activities in detail and afford a comparison of volume and efficiency of operations.

During the last four years the division has made an increasing use of old employees from other departments who were no longer able to carry on their regular duties, also employees of all ages who are recuperating from physical and mental ailments. Some of the latter are returned to their respective departments if they recover sufficiently. Whether these men stay with the division or return to their original departments, the company feels that it has helped them retain their self-respect by keeping them gainfully employed and regards this as "human salvage." This branch of the work, states Mr. Campbell, has been very satisfactory, both as to the utilization of these employees and the cost and quality of the work performed.

The salvage division is a branch of the stores department of the company and has a wide scope of duties in connection with salvage matters. All materials and equipment retired from a plant are turned over to the division as soon as the writeoffs are made. Members of the division supervise the actual removal and disposition of materials in most cases, which sometimes involves the dismantling of entire powerhouses and substations. Scrap is disposed of directly from the point of removal and items which are to be retained for sale or further use are transferred to the salvage division's building. All sales are under the supervision of the purchasing department.

During the years 1935 to 1938, inclusive, the volume of salvage business of the division has averaged close to the million-dollar mark. This includes salvage sold outside the company, and salvage materials and equipment reconditioned and used within the company. The division has become a dependable source of supply for many departments of the company and the items produced by it are subject to the same stringent inspection as purchases from outside vendors. The success of the salvage division has been greatly due to the fine cooperation of the company's engineers and using departments, who have become "salvage-minded" to the extent that they give full consideration to the possible uses of salvage materials and equipment on all their projects.

An appendix which accompanies the paper gives a good idea of the nature of the operations of the salvage division. Included in the operations are wire reclamation, salvage-furnace operation, transformer repairing and rebuilding, reclamation of small items (bench work), tool repairing, preparation of scrap metal for sale, woodworking operations, waste-paper baling, pole reclamation and salvaging, lead-cable reclamation, scrap-iron storage, spray galvanizing, and handling and storage of materials and equipment. Combined with the division is a testing laboratory and office.

Proposed Standard Tractor Fuel

AGRICULTURAL ENGINEERING

STANDARDIZATION of tractor fuels, particularly those fuels heavier than the gasolines which are to be used in conventional low-compression tractor engines of the spark-ignition type, is being sponsored by the American Society of Agricultural Engineers at the request of state governmental agencies, the oil industry, and other technical societies. The Committee on Tractor Fuels of the Society sets forth in an article in the April, 1939, issue of *Agricultural Engineering*, a proposed specification for a standard tractor fuel.

Table 1 and the accompanying chart in Fig. 5 give the proposed specification. The suggested name is "No. 1 Tractor Distillate." The prefix "No. 1" seems desirable because at a later date other grades may be described. It is suggested that the minimum octane number shall be 30. The maximum distillation temperatures at the 10 per cent point of 400 F, the 25 per cent at 420 F, the 95 per cent at 515 F, and the end point at 540 F are believed to be low enough to assure good performance in most tractors. The 10, 25, and 95 per cent points were chosen because several states use those temperatures in describing their upper distillation limit of motor-vehicle fuel which is taxable, and also because the Western Petroleum Refiners Association use these percentages in describing their standard distillate.

TABLE 1 PROPOSED SPECIFICATION FOR "NO. 1 TRACTOR DISTILLATE"

Name:	No. 1 tractor distillate	
Octane number:	30 minimum	
Distillation:	Minimum:	5 per cent point not lower than 325 F
		95 per cent point not lower than 464 F
	Maximum:	10 per cent point not higher than 400 F
		25 per cent point not higher than 420 F
		95 per cent point not higher than 515 F
		End point not higher than 540 F

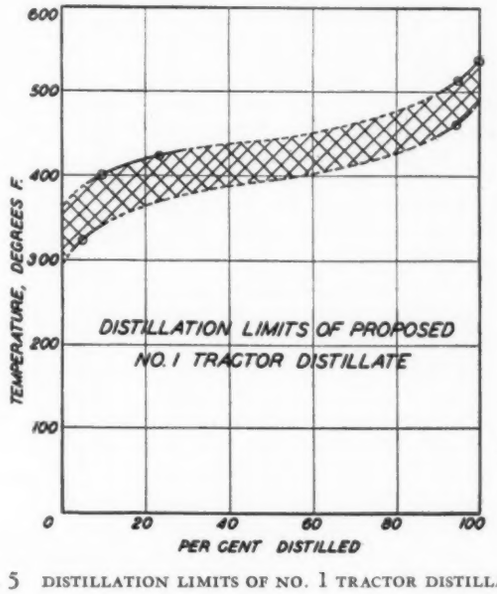


FIG. 5 DISTILLATION LIMITS OF NO. 1 TRACTOR DISTILLATE

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Cottonseed Processing Research

To the Editor:

Reporting for the A.S.M.E. Special Research Committee on Cottonseed Processing, Dean Woolrich has presented the technical history[1] of some engineering investigations for an industry which is ordinarily thought of in connection with the nation's supply of vegetable oils. Additional details concerning oil yields and the qualities of the oils produced by the new pressure cooking process are available in another progress report.[2] Results point to a potential increase in oil yield of about 45,000,000 lb annually, if the new process were universally used.

The importance of this industry in the national economy is indicated by the fact that we import about a third of our oils and fats, including some 60,000,000 lb of cotton oil annually. It is also an industry the operations of which profoundly affect agriculture, as the author has pointed out in referring to the fact that cottonseed contains valuable fertilizer elements. After the oil has been extracted, the remaining cottonseed meal carries over 40 per cent of protein, and is the largest domestic source of vegetable-protein animal feeds. The shipment of cottonseed and cottonseed meal during the last 75 years has been a major cause of the exhaustion of the soil of the cotton belt. When fed to livestock, as much as 80 per cent of the fertilizer content of the meal may be continuously returned to the soil. It is extremely desirable, therefore, that the meal be distributed locally to the greatest possible extent, and that cotton farmers introduce livestock into their farm-management programs. The presence of livestock brings more grass and pasture, cover crops which control erosion.

In North Carolina this has already taken place to the extent that the consumption of cottonseed meal within the state equals the production. Note that North Carolina is a state in which small local cottonseed mills are dominant; 90 per cent of them are of this character, handling less than 10,000 tons of seed a year each, which corresponds to an annual gross business of the order of $300,000. Such small mills seem naturally to exchange cottonseed meal for the farmers' cottonseed, or to sell cottonseed meal locally, thus encouraging livestock and agricultural diversification. In Mississippi on the other hand, where most of the meal is shipped away, only 43 per cent of the mills are in the small class, as previously defined.

Soybeans, a competing source of protein feeds, are beginning to conquer midwestern and northern markets, thus forcing the cotton South to use its own cottonseed meal.

Tests are now under way to adapt the cooking equipment for the extraction of oil from other oil-bearing seeds such as flax, and from peanuts. If successful, the length of the operating season for a small mill might be increased. At present the overhead in a typical mill must be carried by cottonseed only, during an operating season averaging five months.

If it is to survive, the small cottonseed mill must have earnings sufficient to improve its equipment and keep up with the procession of technical advance in the industry. The development described by the author was carried out with this in mind. Few independent businesses of this size can alone carry the cost of substantial research programs; the pioneer work described is a significant illustration of what a state engineering-research laboratory can do.

Business adopts new processes and invests in new equipment only after trying them out in pilot plants. In order to be sure that the new process could be safely adopted by the small oil mills the University of Tennessee decided to set up a pilot plant. The industry contributed or loaned all the needed equipment except the cooker and a supply of cottonseed. The Tennessee Valley Authority's Agricultural Industries Division designed and built a full-sized pressure cooker (shown in Fig. 2 of the paper). On its campus the University of Tennessee constructed a new building large enough to house the new equipment.

Reports from the industry indicate that the results will have a high commercial value, approximately $1 per ton of seed processed at present price levels, and a potential addition of several million dollars annually to the value of the cotton crop. Improved processes for the cotton oil extraction mill, however, will not alone meet the problem. A practical business study has been made of the practice of marketing cottonseed meal in rural areas, in order to determine what factors affect the sale of cottonseed meal locally, and how the new process can be used to further this practice.

It will be interesting to watch the course of the introduction of the process in the industry, and observe the extent of its effect upon agricultural practices. Many spokesmen of business, agriculture, and government have during the last few years advocated greater integration of agriculture and industry. This principle has most often been proposed in general, without specifying where and how. The development we have been discussing may possess significance beyond its technical results and beyond any immediate economic value. First, it may well bring about a better coordination in fact between agriculture and an established agricultural industry, the operations of which profoundly affect the entire cotton belt. Second, it constitutes a concrete example of effective cooperation between private business and public technical research.

So far, pressure cookers have been built under patent license by the Davidson-Kennedy Company of Atlanta, Georgia, and the French Oil Mill Machinery Company of Piqua, Ohio. Units built to approved designs have been installed by the Planters Oil Mill, Greenwood, Mississippi, the Taylor Oil Mills, Moultrie, Georgia, and the Terminal Oil Mill, Oklahoma City, Oklahoma.

John P. Ferris.[3]

To the Editor:

The author is to be complimented upon his paper on cottonseed processing. This

[1] "Cottonseed Processing Research," by W. R. Woolrich, Mechanical Engineering, February, 1939, pp. 131–135.

[2] "Experiments in Cottonseed Processing Conducted by the Engineering Experiment Station of the University of Tennessee in Cooperation With the Tennessee Valley Authority," a report by the Engineering Experiment Station, Knoxville, Tennessee, published in Proceedings of the 42nd annual convention of the National Cottonseed Products Association, Inc., May, 1938.

[3] Director, Department of Agricultural Industries, Tennessee Valley Authority, Knoxville, Tenn. Mem. A.S.M.E.

is a subject of which there has been little known in this country. The industry has been satisfied to employ ineffective cooking equipment and has neglected to attempt the removal of guesswork from its operations in the crude mill. Mechanical engineers have overlooked a fertile field for proving that makeshift operations will not help to promote efficiency.

In 1919, the writer undertook, in collaboration with Mr. Madras, assistant superintendent of the Memphis, Tenn., plant of the Southern Cotton Oil Company, a research project in the mechanical processing of cottonseed.

The industry had realized for years that the makeshift cooking process was responsible for the low yield of oil from the meats. Samples analyzed would show as little as 3 per cent and as much as 12 per cent of the oil left in the cake. The extreme difference might be found in samples taken from the same cooker within the hour.

In our pilot plant we strove to determine the proper cooking procedure. It was generally recognized that there were two vital factors, namely, temperature and time, in cooking meats to obtain maximum yield of oil. A few of the operators also made an effort to control the moisture of the meats during the cooking process.

We supplemented our work in the pilot plant with a study of the cell structure under the microscope. To this study we attributed our partial success in the cooking operation.

We learned that the individual cell is protected by a tough epidermis and that it could not be broken by temperature alone. In fact, we learned that as the cell was slowly heated it would rupture the epidermis and release the oil at a fairly definite temperature when touched by a drop of water.

Cooking several cells on the slide of a microscope proved beyond a doubt that temperature and moisture content of the meats were the determining factors in the cooking operation necessary to obtain maximum extraction of oil. But how to interpret the observations under the microscope and utilize them in practice was the real problem.

Our batch cooker was not an effective piece of equipment. It was a steam-jacketed pot with a revolving scraper on the bottom and held about twenty pounds of meats. The meats could not be tumbled about as they should have been. In cooking, one factor at a time was varied while the others were maintained constant. Following are the factors which were considered in each cooking program:

(1) Moisture content of meats
(2) Time of rise from room temperature to cooking temperature
(3) Cooking temperature
(4) Total time of cooking operation.

Most of the cooking tests were performed under atmospheric pressure. A few pressure and vacuum cooks were tried but we were not encouraged with the results. Our original purpose was to devise a cooking schedule which would consistently remove all but 3 per cent of the oil from the cake.

Several months were required for the tests and toward the end of the project it was necessary to process damaged meats; instead of being yellow they were chocolate colored. In cooking damaged meats we invariably produced a chocolate-colored meal and a dark oil. However, one test proved to be startling, in that a bright-yellow meal and almost a water-clear oil were produced from the damaged meats. The oil extraction was not anything remarkable, about 95 per cent.

This test was repeated over and over again, following out carefully the identical cooking cycle but we were unable to obtain duplicate results. Had we been able to do this, the industry would have benefited to the extent of millions of dollars, as the meal is sold on a color basis to the feed and fertilizer manufacturers. The costly operation in the refinery is the removal of the amber color.

From our series of tests and microscopic observations we drew only one conclusion. There must be a critical temperature at which a definite amount of moisture releases the large yield of oil.

Our failure to duplicate, we attribute to the crude equipment we employed and to the fact that the temperature and moisture content of the meats were not properly measured.

VICTOR WICHUM.[4]

TO THE EDITOR:

The history of the work of Messrs. Wichum and Madras has been an inspiration to many cottonseed-oil-mill superintendents for the last twenty years. The fact that bright meal and oil had been produced from badly discolored seed in the experiments of these two men was ever an incentive to the operators to try to repeat the performance. Mr. Wichum's pioneer work is the forerunner of the series of researches reported by the writer in MECHANICAL ENGINEERING, February, 1939.

Mr. Ferris in his communication has reflected the serious economic aspect of the mass movement of cottonseed meal from the agricultural areas of the South. The new process of pressure cooking under controlled conditions is so admirably adapted to small-plant production on an economic basis that it might profitably supersede the existing large-plant operations.

W. R. WOOLRICH.[5]

[4] Sales Engineer, C. J. Tagliabue Manufacturing Company, Brooklyn, N. Y. Mem. A.S.M.E.

Economics of a Power Plant for Joint Utility and Industrial Service

TO THE EDITOR:

To read the authors' paper[6] on the interesting development at Baton Rouge is to admire the part there played in the further achievement of the long-cherished ideas of engineers economically to correlate central-station facilities with the requirements of those manufacturing industries which are affected by process-steam, waste-heat, or waste-fuel operations. A visit to this unusual plant at Baton Rouge also impresses one with the capable handling of the physical problems. In addition, the terms under which the arrangement was made, as outlined in the paper, indicate that the advantages and responsibilities are being equitably shared. It is desirable for an engineering group to give its thought and attention to the financial as well as the technical phases surrounding special developments of this character.

It will be of interest, no doubt, to refer to the valuable contribution made by H. Drake Harkins[7] at the 1933 A.S.M.E. Annual Meeting. Different possibilities and conditions of interchange were dwelt upon by Mr. Harkins and in addition he presented a partial list of actual cases wherein the principle of economic use of by-product or interchange had already been applied. Incidentally, the Baton Rouge plant happened not to be included in the list. The record of the latter would appear to deserve special mention for two reasons: First, recent extension of the term of the contract indicates that the original planning was sound; and second, other industries have since been induced to locate at this site and employ similar arrangements, thus widening the

[5] Dean of Engineering and Director of the Bureau of Engineering Research, The University of Texas, Austin, Texas. Mem. A.S.M.E.

[6] "Economics of a Power Plant for Joint Utility and Industrial Service," by A. C. Klein and T. E. Crossan, MECHANICAL ENGINEERING, February, 1939, pp. 121–124.

[7] "Cooperation Between Industrial and Public-Utility Companies in Generating Steam and Electricity," by H. D. Harkins, Trans. A.S.M.E., vol. 57, 1935, paper FSP-57-2, pp. 11–17.

application of economical utility-industry development at this center.

The fact that we are constantly experiencing increasing governmental supervision might also be worthy of comment in this connection. It is to be hoped that all supervisory power will be wisely exercised because any action to the contrary could obviously have a deterring effect upon developments of the kind under discussion. When thinking becomes confused, because of treating primarily with average kilowatthour costs, economic progress is bound to be retarded. In a case like this it is the incremental dollar costs that must guide both interests in their decision in any plan of coordination. Because the low kilowatthour rate, which results from special coordination and mass consumption of energy, may be improperly regarded as subsidizing the larger power user at the expense of other consumers, that fallacy must be guarded against. The real test, of course, is whether the business is better off with or without such added load, and this depends upon whether the revenues to be obtained under the contract adequately cover the new expenses including the fixed charges occasioned by such load. It is to the benefit of all rate payers that economies realizable on such incremental basis be promoted. The use of average kilowatthour costs would inevitably preclude such helpful interdevelopment programs which insure both the best use of capital and the conservation of our natural resources.

While the benefits even to the residential consumer would eventually be reflected in some degree in their individual accounts, due to the economies achieved, the important result in fostering complete coordination is the greater security and prosperity for the people of the community, as a whole, which will follow the development of stronger commercial and industrial enterprises. Neither can the long-established fact that capital is timid be overlooked, and both utility and industry must approach the investment problem with caution. Any interdevelopment of utility and industry must be made upon a mutually profitable basis. If unexpected changes take place, the economics of the situation may be seriously upset, and one party to the coordination plan may suffer out of all proportion to the other and inconsistently with the business risk involved.

There exist different latitudes as between the regulated utility and the nonregulated industry, as will be explained. Rates for return and depreciation are now quite definitely limited in case of the former whereas the latter (subject to the competition obtaining) may freely set its own tempo for recovering its capital investment. Those who would justify utilities' being narrowly regulated disregard the fact that over 50 per cent of their power in most cases may be provided by other means of generation if the price to industry for such service is not reasonably in line with that of the possible substitutes. And in this respect the utility has a real problem in anticipating future conditions. It is confidently expected that the various authorities will not overlook this situation in their final conclusions. A plan for utility-industry coordination of the kind under discussion was broadly outlined in the writer's discussion[8] of Mr. Harkins' paper and no attempt will be made to repeat the recommendations. The fact should be stressed that, for future stability, the conditions in each enterprise must be considered fully and carefully. The financial problems of the two interests are likely to be quite dissimilar. As a reminder, with the utility, the ratio of investment dollars and annual earnings is usually high (5 or 6 to 1), while in many industries the turnover of capital may occur every year or two. Because of this the risk factor varies considerably and that fact must be recognized in striking a fair balance in fixing the contractual terms. In these matters engineers must of necessity take a prominent part. The Baton Rouge plant provides an example of the practical handling of these vital considerations.

EDWIN D. DREYFUS.[9]

Combustion of Wood-Waste Fuels

TO THE EDITOR:

The author has presented an excellent paper[10] concerning the different phases of the combustion processes which take place in the burning of wood-waste fuels. He has given useful data showing the effect of moisture content on the temperature of combustion and the heating value of the fuel. The benefits of preheating air for combustion and of drying the fuel before burning have been clearly shown. The writer would like to discuss several forms of furnaces each of which possesses certain advantages for different classes of wood refuse.

The Dutch oven with flat grate as illustrated in Fig. 5 of the paper, is well adapted to burn refuse in the form of sawdust, shavings, chips, and small blocks or cuttings. The flat grate, if of proper design, may also be used for auxiliary firing with coal if necessary, at times when wood refuse is not available. For burning refuse wood too much emphasis cannot be given to the desirability of supplying air under definite pressure through the furnace walls by means of nozzles properly designed to produce high air velocity and directed obliquely downward toward the fuel bed. Nearly all the combustion takes place from the surface of the pile of fuel and little from air supplied through the grate. This method of supplying air through the side walls above the grates should also be used when wood refuse is burned on a fuel bed of coal as with horizontal single-retort stokers. Such installations may be used when the quantity of wood refuse alone is not sufficient for the fuel requirements. The secondary air under pressure at the rear of the Dutch-oven roof is important to burn out any hydrocarbons not consumed in the furnace. This air should have regulated control so that too much excess air may not be admitted at this locality.

The conventional design of furnace for burning pulverized coal, preferably with water-cooled side walls and a flat hearth without grates, is well adapted for burning kiln-dried or air-dried wood refuse. The fuel is fed into the furnace by chutes through the front wall near the top and much of the finer material is burned in suspension. Air under pressure should be admitted through nozzles in the side walls directed downward toward the center of the furnace floor. Whatever fuel is not burned in suspension is promptly consumed on the furnace hearth without piling or covering the hearth surface. The furnace should be proportioned so that the upward flow of gases will not carry the burning cinders into the boiler tube bank. Several designs are shown in a paper[11] presented by the writer before the A.S.M.E. in June, 1930, at Detroit, Mich. Figs. 11, 12, and 13 in this paper illustrate the method of installing air nozzles or tuyères in the side walls near the furnace hearth and the general proportions of furnaces designed to burn dry refuse.

For larger boiler installations, particularly if the fuel contains over 15 or 20 per cent moisture, the inclined step grate with Dutch oven having a downward-sloping roof at the rear is desirable. A horizontal dumping grate at the bottom of the sloping grate is usually provided in front of the bridge wall. Here too, air under pressure should be admitted

[8] Trans. A.S.M.E., vol. 57, 1935, p. 18.

[9] Engineer, Pittsburgh, Pa. Mem. A.S.M.E.

[10] "Combustion of Wood-Waste Fuels," by Henry Kreisinger, MECHANICAL ENGINEERING, February, 1939, pp. 115–120.

[11] "Boiler Settings for Burning Refuse Wood," by C. S. Gladden, Trans. A.S.M.E., vol. 53, 1931, paper FSP-53-3.

through the bridge wall directed forward toward the fuel bed, and also secondary air at the throat of the furnace just after the gases pass over the bridge wall. In this type of furnace the moisture is evaporated in the upper portion of the sloping fuel bed; as the dried fuel slides downward the volatile gases are driven off and ignited, and finally the cinders, charcoal, and embers burn in the lower zone of the inclined fuel bed. This method of burning wood refuse is progressive and there is no blanketing of burning fuel by the fresh fuel fed into the furnace. This design of furnace is applicable to a wide variety of wood refuse, bark and shavings from pulp wood, sawdust and slabs from saw mills, and "hogged" wood, sawdust, and shavings from dry-lumber operations. Typical designs of this furnace are also shown in Fig. 4 of the writer's paper,[11] and in Figs. 15 and 18 of the discussions following the paper.

Finally, peculiar fuel conditions require a refractory grate. Where large long shavings and cuttings are fed through a chute, as in the furnace illustrated in the author's paper,[10] combustion takes place at once at the surface of the grate and as more fuel is piled on top of the burning mass the grate becomes overheated and burns out. A refractory grate which is well designed will usually be found to prove satisfactory for such cases.

CHARLES S. GLADDEN.[12]

TO THE EDITOR:

Mr. Kreisinger's paper deals with the subject of burning wood waste from a logical point of view and brings out several points worthy of discussion.

One important statement which can easily be substantiated in most plants is that a temperature of at least 1100 F is necessary for ignition of the volatile matter distilled from the bark. There is considerable room for improvement in maintaining that temperature in actual operation.

Mr. Kreisinger states that only 10 per cent of the total air supply should be admitted under the grates. While several authorities advocate this, it has been my experience that, to obtain a high rate of combustion, as much as 75 per cent of the air should be admitted under the grates. If highly preheated air is used it may be possible to produce enough heat with 10 per cent of the air supply to drive off the volatile matter but apparently with air at room temperatures it is not always successful in practice. It would be of great interest to obtain data on operation with highly preheated air. The reason why more than 10 per cent of the air supply (particularly with moisture in excess of 60 per cent) appears necessary under the fuel bed, is because in order to burn the char completely, a large amount of excess air must be supplied, due to the fact that the bark burns chiefly on the surface and around holes in the fuel bed and all the air cannot be brought in contact with the glowing charcoal. It is also questionable if the heat liberated is sufficient to evaporate the moisture without some assistance from the burning volatile matter.

It would appear at the present time that the best type of furnace for bark burning is of the Dutch-oven type in which the following features have been incorporated:

(1) Some means, such as shaking grates, to agitate the fuel bed and remove ashes
(2) An ignition arch to maintain gases above the ignition point and to give turbulence to the gases in the combustion chamber
(3) A furnace, long as compared to its width, say, about twice as long as it is wide.

One of the major problems of the northern mills is that of maintaining a sufficiently high rate of combustion to dispose of the bark as it is produced, in order to avoid costly furnace and boiler capacity which would be idle a great part of the year. In this connection improved methods of preparing the bark for the furnaces are needed. Presses, hogs, driers, and conveyors are expensive considering their capacity and it is often cheaper to use auxiliary fuel than to press, hog, and dry the bark properly before burning.

Mills which generate all or part of their electrical power often desire to burn the bark under their high-pressure boilers and a more successful design of furnace and boiler which will be capable of burning bark as well as coal would be of great benefit to such plants.

ARNOLD A. SMITH.[13]

To the Editor:

Mr. Gladden's discussion contains much useful information on the burning of wood-refuse fuels. He points out the desirability of supplying overfire air under pressure through furnace walls. The pressure produces high-velocity air jets which supply the energy necessary for the mixing of this air with the combustible gas. When the overfire air is supplied with natural draft available in the furnace, the velocity of such air is too low and the air does not penetrate into the stream of combustible gas rising from the fuel pile. Under such conditions the air flows along the walls and mixes with the gases very slowly. As a result the combustion of the gases is slow and usually extends into the boiler resulting in smoke and loss of heat.

When highly volatile bituminous coal is burned on a grate, overfire air is supplied in high-velocity jets to prevent smoke. Such coal contains about 40 per cent volatile matter. Wood-refuse fuel contains about 80 per cent volatile matter which must be mixed with air and burned in the combustion space. Supplying overfire air in high-velocity jets is, therefore, even more important in burning wood-refuse fuel than it is with bituminous coal, if complete and smokeless combustion is to be obtained. As pointed out in the paper the volatile matter should be burned in the Dutch oven close to the fuel pile in order that the heat generated by the combustion of the volatile matter will be available for driving off the moisture and the volatile matter from freshly fired fuel.

Mr. Smith's discussion refers to the burning of tree bark containing 60 per cent or more moisture. The high moisture content makes the burning of tree bark difficult because a large quantity of heat is needed to drive off the moisture before combustion of the fuel can be started.

The disagreement in connection with the amount of air to be supplied through the grate is only apparent. Mr. Smith considers the problem from a different point of view. Fig. 5 in the paper shows a conical fuel pile free from holes. The fuel is fed to the furnace through fuel chutes in the furnace roof. It falls on the apex of the fuel pile and rolls down the sloping sides. Most of the volatile matter is driven off at the surface of the sloping sides of the pile. Sufficient quantity of air must be supplied over the fire to burn this volatile matter.

The fuel pile consists largely of glowing char with a layer of freshly fired fuel at the top and no holes in the fuel bed. It is impossible to force air through the glowing char for the burning of the volatile matter coming off the top of the fuel pile. The oxygen of the air is all consumed in the formation of carbon

[12] Mem. A.S.M.E.; formerly associated with Combustion Engineering Company, Inc., New York, and with General Motors Corporation, Detroit, Mich., as director of power and maintenance section.

[13] Steam Superintendent, Three Rivers Mill No. 16, Canadian International Paper Company, Quebec, Canada.

monoxide with the fixed carbon in the char before the air reaches the top of the fuel bed where the volatile matter is coming off. If attempts are made to force more air through such a fuel bed, more of the fixed carbon in the char is converted to carbon monoxide, and the gases contain no free oxygen when they reach the top of the fuel bed. If the increased rate of gasification of the fixed carbon is continued the thickness of the fuel bed is reduced to such extent that holes begin to form caused by burning of the char as well as by its being blown away by the high velocity of the air.

Mr. Smith has in mind fuel with moisture in excess of 60 per cent burned in a fuel pile containing holes. He states that the bark burns chiefly on the surface and around the holes in the fuel bed. The holes in the fuel bed may be the result of burning out or blowing away of the char combined with uneven feeding of fresh fuel. A short analysis of such a condition shows the logic of his statement that supplying about 75 per cent of the air through the grate gives better results.

Let it be assumed that the fuel contains 60 per cent moisture. This means that 0.6 lb of water must be evaporated from the fuel before combustion can be started. If the fuel is to be burned at the rate of 200 lb per sq ft of grate area, which is not considered a very high rate, there would have to be evaporated 120 lb of water per sq ft of grate per hr. Inasmuch as it takes about 1000 Btu to evaporate a pound of water, about 120,000 Btu would have to be transmitted to the freshly fired fuel per square foot per hour. This is a high rate of heat transfer and would require a very high temperature above the fuel bed. Let it be assumed further that the fuel bed is on the average 2 ft thick and that there is a 4-in. cylindrical hole for each square foot of grate area. The inside surface of each cylindrical hole will be a little over two square feet, which is twice as much surface as there is at the top of the fuel bed.

Volatile matter will pass from the fuel into these holes and flow through them to the top of the fuel pile. The air that is supplied through the grate, flows through these holes and mixes with the volatile matter with the result that a considerable part of the volatile matter burns within these holes. The heat generated by the combustion of this volatile matter will be quickly transmitted by convection and radiation to the fuel in the sides of the holes, and drive off the remaining moisture and the volatile matter. Thus, each hole in the fuel bed will act as a small furnace. On account of the greatly increased surface which is nearly three times the amount of the surface at the top of the fuel bed, the rate of heat transfer required for driving off the moisture instead of being 120,000 Btu per sq ft per hr needs to be only 40,000 Btu which is well within the limit of possibility. The holes in the fuel bed furnish means of generating heat close to the fuel, thus making the heat available for driving out moisture and the volatile matter, which is one of the fundamentals of combustion of high-moisture wood-waste fuel stated in the paper.

It is not difficult to extend such conditions a little further and have enough holes in the fuel bed or fuel pile to supply all the air needed for combustion of the fuel through the grate. The bad feature of such method of supplying air for combustion is that the quantity of air cannot be controlled with any degree of accuracy. The holes change in size, new holes are formed and some of the old holes may be filled by caving of the fuel. Perhaps from Mr. Smith's point of view this objection is not serious. He apparently looks on tree bark as something to be rid of quickly and not as a fuel to be burned efficiently.

The statement that bark burns chiefly on the surface and around the holes in the fuel bed is true only of the fixed carbon. The volatile matter comes off as a gas and burns in the space as soon as it is mixed with air. The fixed carbon cannot leave the solid fuel as gas but must wait until oxygen makes contact with it to convert it to carbon monoxide or dioxide before it can leave the char as gas. Naturally the contact of the oxygen with the fixed carbon takes place at the surface of the pieces of char.

A high rate of combustion of wet tree bark is the problem of burning the bark in such a way that the heat generated by the combustion is available for driving off the moisture. The bark can be burned only as fast as moisture can be driven from it. The heat produced by the combustion can be made available for driving off the moisture if it is generated close to the freshly fired fuel, that is, the heat must be generated in the Dutch oven and not in the secondary combustion chamber or among the boiler tubes.

The author wishes to call attention to a typographical error in Table 1 of his paper as published. The heat value of California Redwood determined by the Bureau of Mines is 9220 Btu instead of 9920 Btu.

HENRY KREISINGER.[14]

[14] Engineer in charge of research and development, Combustion Engineering Company, Inc., New York, N. Y. Mem. A.S.M.E.

"Back Talk"

TO THE EDITOR:

One of the inalienable rights of a member of our Society is talking back to the Editor and Publication Committee. And I feel that the Editor is broadminded enough to publish this back talk. The cause is the publication in MECHANICAL ENGINEERING and our Transactions of papers and articles not relating to mechanical engineering, but to sociology and economics. Many such have been published in the last ten years. Does the Editor think they have had any real effect in shaping the course of world affairs? On the other hand, the Editor can be proud of the effect on engineering progress, of the papers that he has published on strictly engineering subjects.

A comparison between the real usefulness of scientific papers and other sorts is so well made by Bernard De Voto in the "Easy Chair" in the March *Harpers Magazine* that an extended quotation will make my point better than I can in my own language. Speaking of scientists in general, he says "Elsewhere scholars might fret and chill with doubt of what they were doing, but not these scholars. . . . They are a more severe, more confident group than their colleagues in the social sciences and the humanities . . . . . Scientists . . . . . know what they are talking about, as sociologists and their ken commonly do not. . . . . They know that even the humblest paper of the humblest chemist . . . . . will be useful to someone . . . . . whereas the reports . . . . . that humble sociologists compose . . . . . will just be dumped forever on the garbage heap of a self-perpetuating vested interest. . . . . And they know that sometimes in small, drowsy rooms, where a few aging men gather, papers are read which will ultimately change the face of nature and the form of society. No paper read at . . . . . the American Sociological Society, past, present, or to come, will have any effect whatever on either nature or society."

When the Editor publishes a paper on a new sort of machine tool or a new item in flow of fluids, he can well hope that it will change the "face of nature" as many of our engineering papers have in the past. But let the Editor look back at some of the papers on economic subjects that he published say five years ago, when I wrote a letter similar to this to our Publication Committee. Can he honestly say that they have had an effect on the world's progress worth the cost to the Society of printing them?

SANFORD A. MOSS.[15]

[15] Consulting Engineer, General Electric Co., West Lynn, Mass. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the committee and passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechainical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of May 26, 1939, which were subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 768 (Annulled)

CASE No. 850 (Reopened)

(*Interpretation of Pars. P-105c and U-74*)

Inquiry: On the basis of test data submitted, will it be permissible to modify the requirements of Pars. P-105*c* and U-74 to permit drilling tube holes $^1/_8$ in. from the edge of a weld made in accordance with the requirements of Pars. P-101 to P-109, inclusive, P-112, or U-68?

Reply: On the basis of the data submitted, it is the opinion of the Boiler Code Committee that from a safety standpoint, it is permissible to modify Pars. P-105*c* and U-74 to allow unreinforced holes to be machine cut through welds made in accordance with Pars. P-101 to P-109, inclusive, P-112, or U-68; but as it may be difficult to properly expand or roll tubes into holes where the metal around the entire circumference may be of varying hardness, tube holes for rolled or expanded tubes shall not be placed closer to a weld than $^1/_4$ in. from the edge of the fused metal.

CASE No. 876 (*Special Ruling*)

Inquiry: Is it permissible under the A.S.M.E. Boiler Code to use flexible staybolts in which the cover cap is welded to the outer sheet in the construction of locomotive-type boilers? Such staybolts would be located in the two upper rows of the throat sheet and in three horizontal rows in the wrapper sheet, two rows of which would be immediately above and one horizontal row immediately below the tangent point at the side of the sheet.

Reply: It is the opinion of the Committee that such staybolts may be used at the stated locations, provided the bolt is hollow drilled from the threaded end into and partly through the ball head to allow for proper inspection and so that any breakage is disclosed by leakage at the inner end, and provided that the caps are welded by men qualified under the provisions of Par. P-112. The welded joint need not be stress relieved or X-rayed.

CASE No. 877

(*Interpretation of Pars. U-64 and U-77*)

Inquiry: Many welded pressure vessels are made with the expectation of galvanizing them after completion. In order to avoid duplication of the hydrostatic test required by the Code for Unfired Pressure Vessels, may the test be applied after galvanizing?

Reply: It is the opinion of the Committee that the hydrostatic test required by Pars. U-64 and U-77 may be applied to a Code pressure vessel after it has been galvanized.

CASE No. 878

(In the hands of the Committee)

Books Received in Library

AIR CONDITIONING. By B. H. Jennings and S. R. Lewis. International Textbook Co., Scranton, Pa., 1939. Flexible, 6 × 9 in., 467 pp., illus., diagrams, charts, tables, $4. The fundamentals of air conditioning are presented in this textbook in adequate amount to form a working basis for the engineering student or the practicing engineer. The emphasis is on basic principles, although conventional methods of empirical treatment are given in some cases. Ordinary heating methods and refrigeration are considered at some length. Illustrative examples, problems, charts, and tables of data add to the reference value of the book.

AIR-CONDITIONING ENGINEERS' ATLAS. By C. Strock and C. H. B. Hotchkiss. Industrial Press, New York, 1939. Cloth, 9 × 12 in., 72 pp., maps, tables, $2. This publication presents, in condensed and readily usable form, the weather data needed by engineers in solving problems of heating and cooling. Eighteen maps of the United States, colored in zones, show the various phases of summer and winter weather which are of concern in the heating industry. Accompanying these maps are supplementary tables giving the data for the larger cities.

AIR CONDITIONING, Fundamental Principles, Practical Installations and Ozone Facts. By E. W. Riesbeck. Second revised and enlarged edition. Goodheart-Willcox Co., Chicago, 1939. Flexible, 5 × 8 in., 443 pp., illus., diagrams, charts, tables, $3.50. This practical book, written in a nontechnical manner, explains the principles of air conditioning, differentiates between conditioning and cooling, describes methods, equipment, installation and adaptation, and shows how to figure requirements. Refrigeration, the use of ozone, and water sterilization are treated as allied subjects.

ALLOY CAST IRONS, published by American Foundrymen's Association, 222 West Adams St., Chicago, 1939. Leather, 6 × 9 in., 257 pp., illus., diagrams, charts, tables, $3. The manufacture, uses, and properties of modern alloy cast irons are discussed in this volume. The major portion of the book is devoted to the effects of various alloying elements on the physical and mechanical properties of gray irons, with chapters on foundry practice and heat-treatment, and a table of specific applications. There is a large classified bibliography.

ARBEITSMAPPE DES HEIZUNGSINGENIEURS, Sammlung der auf den neuesten Stand ergänzten Arbeitsblätter aus der Zeitschrift "Heizung und Lüftung." V.D.I. Verlag, Berlin, 1939. Paper, 9 × 12 in., 33 pp., charts, maps, tables, 3.50 rm. This collection of the tables and charts which have appeared at intervals in "Heizung und Lüftung" presents for ready reference many numerical data useful in the planning, calculation, and investigation of heating and ventilating installations.

ARC WELDING IN DESIGN, MANUFACTURE, AND CONSTRUCTION. James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, Lincoln Electric Co., 1939. Leather, 1408 pp., illus., diagrams, charts, tables, $1.50 in U.S.A.; $2 in foreign countries. Of the more than 400 papers which received awards from the James F. Lincoln Arc Welding Foundation, 109 have been selected and published in this volume. The papers describe the designing or redesigning of some machine, structure, building, or manufactured product of ferrous or nonferrous metals for the use of arc welding in its production. The subjects of the selected papers have been chosen from the 44 subclassifications to afford the widest possible variety, and a majority have been presented in full. There is a subject index.

BETRIEBSTECHNISCHE SAMMELMAPPE, 1. Ergänzungslieferung. Die gesammelten und überarbeiteten Blätter des Betriebsarchivs aus den letzten Jahrgängen der Zeitschrift *Maschinenbau-Der Betrieb*. DIN A 4. V.D.I. Verlag, Berlin, 1939. Paper, 9 × 12 in., 24 pp., diagrams, charts, tables, 2.40 rm. This collection of data sheets supplements the one issued by *Maschinenbau-Der Betrieb* in 1937, and consists of sheets published in the periodical

since that time. They give brief practical summaries on various pieces of shop equipment tools, heat-treatment, testing methods, etc.

COMPLEX VARIABLE AND OPERATIONAL CALCULUS WITH TECHNICAL APPLICATIONS. By N. W. McLachlan. University Press, Cambridge, England; Macmillan Co., New York, N. Y., 1939. Cloth, 6 × 9 in., 355 pp., diagrams, charts, tables, $6.50. The author has based his theory of operational procedure on the Mellin inversion theorem, a combination of complex integration and the Laplace integral, and the main treatment appears in part 2 of the book. Part 1 contains an exposition of the theory of the complex variable, covering the technique of complex integration. In part 3 the application of the foregoing method to problems in various branches of technology is illustrated. There is a section of examples to be worked out. Certain specific derivations and a large list of references are appended.

DICTIONNAIRE INTERNATIONAL DE FONDERIE, edited by Association Technique de Fonderie. Partie Francaise (Première Partie) 1938. Cloth, 4 × 6 in., 334 pp., 50.65 frs. This polyglot dictionary of foundry terms is divided into two sections. In the first more than 800 French technical words and expressions are defined in French, each term having an assigned number. The second section consists of lists of corresponding terms in German, Spanish, Italian, Polish, Portuguese, Czech, English, and American (where differing from English), arranged both alphabetically and numerically for reference to the main part and between languages directly. Translators will find the book useful.

DIESEL HAND BOOK. By J. Rosbloom. Sixth edition. Diesel Engineering Institute, Jersey City, 1939. Leather, 5 × 7 in., 720 pp., illus., diagrams, charts, tables, $5. In this practical manual for operators, fundamentals are presented in simple language. Engine details and auxiliaries and their action are described. The principal American types of engines are presented and practical advice is given on operation, adjustment, and maintenance. The last section contains questions and answers for license examinations for both marine and land service.

ELASTICITY, Part 3. Structure, Strength, and Chemical Action. By C. A. P. Turner, 22 East Gay St., Columbus, Ohio, 1939. Leather 9 × 12 in., 240 pp., manifold, diagrams, charts, tables, $5. A science of thermoelasticity is developed which explains the formation of the elements from ether, heat vibration, gravity, and electrical energy, the mechanics of chemical combination, and coordinates the properties of materials of construction. In the first part thirty-three propositions are stated and developed, laying the groundwork for the following section which elaborates the subject of chemical combination, culminating in the development of the heats of formation of all classes of chemical compounds.

ELECTRIC POWER INDUSTRY. Development, Organization, and Public Policies. By J. Bauer and N. Gold, with the technical cooperation of A. E. Shaw. Harper & Brothers, New York and London, 1939. Cloth, 6 × 10 in., 347 pp., tables, $3.50. This nontechnical presentation of the public aspects of the industry is intended for engineers and economists, and also for the general reader. The development and importance of the electric-power industry are discussed, private organization and management are described, and the problems of public policy and control are considered. A select bibliography is included.

ENGINEERING OPPORTUNITIES. Edited by R. W. Clyne; foreword by K. T. Compton. D. Appleton-Century Co., New York and London, 1939. Cloth, 6 × 8 in., 397 pp., illus., diagrams, $3. Twenty-six engineering opportunities are described in this nontechnical survey of engineering activities in industry. The authors of the various chapters are experts in their individual fields, and in each case show the background of the industry, the present condition of affairs, and the possibilities for the future. A wide range of fields is covered for the assistance of those contemplating engineering as a career.

FAHREIGENSCHAFTEN DER KRAFTFAHRZEUGE. By E. Marquard. R. Oldenbourg, Munich and Berlin, 1939. Cloth and paper, 181 pp., illus., diagrams, charts, tables; cloth, 9.80 rm.; paper, 8.50 rm. In this concise treatise on the riding characteristics of automobiles, the behavior of engines and vehicles under various conditions is discussed and analyzed. Special attention is given to questions of springs, wheel suspension, brakes, and center of gravity. A chapter is devoted to measuring instruments and methods.

FLUGZEUGBERECHNUNG. Bd. 1. Grundlagen der Strömungslehre und Flugmechanik. Bd. 2. Bearbeitung von Entwürfen und Unterlagen für den Festigkeitsnachweis. By R. Jaeschke. Second edition. R. Oldenbourg, Munich and Berlin, 1939. Cloth, 6 × 9 in., illus., diagrams, charts, tables; vol. 1, 174 pp.; vol. 2, 202 pp.; 6 rm. each vol.; 13 rm. for both volumes bound in 1 cover. The first of the two volumes (in one cover) on airplane calculations comprising this book contains the fundamentals of flow theory, their aerodynamical adaptation including the application of investigation results, the flight characteristics of gliders and aeroplanes, and stability determinations. The second volume describes and explains special types of planes (helicopter, rotary wing, etc.), and discusses economy of flight performance, technological design details, and loading considerations. Tables of specifications are given for airplanes of various manufacturers. The many numerical examples of calculations are particularly helpful.

GREAT ENGINEERS. By C. Matschoss, translated by H. S. Hatfield. G. Bell & Sons, London, 1939. Cloth, 6 × 8 in., 381 pp., illus., 12s 6d. This translation from the German contains a series of excellent short biographies of great engineers from antiquity to the twentieth century. It is not only important as an addition to the history of engineering achievement but is of further interest because of the emphasis on the human attributes of these men, their personalities, vicissitudes and ultimate success.

HYDRAULISCHE SCHMIEDEPRESSEN UND KRAFTWASSERANLAGEN. Konstruktion und Berechnung. By E. Müller. Julius Springer, Berlin, 1939. Cloth and paper, 6 × 10 in., 159 pp., illus., diagrams, charts, tables; cloth, 20.40 rm.; paper, 18.60 rm. Lack of modern works on the design of hydraulic presses is the reason for this work, which aims to provide an account of current practice. The various types of hydraulic forging presses are discussed and compared. Calculations are given for their design, and consideration is given to control gear, piping, fittings, reservoirs and auxiliaries. Much of the information is applicable to hydraulic machinery in general.

INTERNATIONAL ASSOCIATION FOR HYDRAULIC STRUCTURES RESEARCH. Report on the First Meeting, Berlin, October 4–7, 1937. Published, 1938, by the Association, President, W. Fellenius, Kungl. Tekniska Högskolan, Stockholm. Cardboard, 6 × 8 in., 286 pp., illus., diagrams, charts, tables, 10 rm. This report on the first meeting of the International Association for Hydraulic Structures Research contains the proceedings of the meeting, lists of the members and participants, and the text of the technical papers presented, covering hydraulic measurements, structures, models, etc.

THEORY OF MACHINES. By T. Bevan. Longmans, Green & Co., London and New York, 1939. Cloth, 6 × 9 in., 549 pp., diagrams, charts, tables, $5.40. Following a brief résumé of the principles of elementary mechanics, the succeeding chapters deal with the various fundamental types of mechanisms, such as gears, cams, belt drives, and so on, and discuss the subject of vibration and balancing. To facilitate the graphical solution of problems, diagrams have been carefully drawn to scale. The answers to the problems given with the text are collected in the back of the book.

LA TURBINE À VAPEUR MODERNE. By E. A. Kraft, translated by W. Maclot. Dunod, Paris, 1939. Paper and bound, 8 × 11 in., 283 pp., illus., diagrams, charts, tables; paper, 115 fr.; bound, 140 fr. This is a translation of "Die Neuzeitliche Dampfturbine," which has also appeared in English in 1931, under the title, "The Modern Steam Turbine." The present translation is based on the 1930 German edition, brought up to date by the author.

ULTRASONICS and Their Scientific and Technical Applications. By L. Bergmann, translated by H. S. Hatfield. John Wiley & Sons, New York, 1938. Cloth, 5 × 9 in., 264 pp., illus., diagrams, charts, tables $4. This is a translation of "Der Ultraschall," which was published in 1937, and apparently is the first English work on the subject. The generation of ultrasonic vibrations, their detection and measurement in gases, liquids, and solids and their practical applications are considered. An extensive bibliography is included.

UNMITTELBARE REGELUNG. By W. Schmidt. V.D.I. Verlag, Berlin, 1939. Paper, 6 × 8 in., 114 pp., diagrams, charts, tables, 12 rm. The aim of this book is to state the principles of governing and regulating mechanisms to develop a general theory, and to illustrate its application to the accurate control of speed, temperature, pressure, and quantity. The characteristics of mechanisms for steady or fluctuating conditions are considered, and the mathematical analysis of regulating processes is discussed. There is a long bibliography.

V.D.I. Jahrbuch 1939. Die Chronik der Technik. Edited by A. Leitner. V.D.I. Verlag, Berlin, 1939. Paper, 6 × 8 in., 298 pp., 3.50 rm. This useful reference work contains over ninety reports by specialists, which review the literature on engineering published during the year 1938. About ten thousand references on all branches of engineering are included. An extensive index facilitates the use of the book.

Die Verbrennungskraftmaschine, Heft 2. THERMODYNAMIK DER VERBRENNUNGSKRAFTMASCHINE, by H. List. Julius Springer, Vienna, 1939. Paper, 7 × 11 in., 123 pp., diagrams, charts, tables, 12 rm. The determination and application of the thermodynamical characteristics of internal-combustion motors are discussed with full mathematical treatment, including many diagrams. The internal efficiency and the relation between the fuel charge and the exhaust gas are treated with considerable detail.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

President Christie to Preside at the Opening Session of British American Engineering Congress

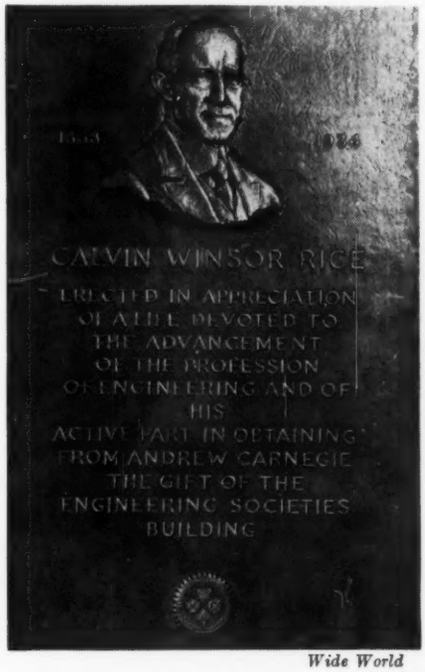
THE designation—British American Engineering Congress—has been selected for the joint meetings to be held in New York during the week of September 4–8, 1939, when The Institution of Mechanical Engineers will meet with The American Society of Mechanical Engineers and The Institution of Civil Engineers and the Engineering Institute of Canada will meet with the American Society of Civil Engineers.

During that week a number of events will be held in which all of the engineers will take part. The program for these events is being shaped up rapidly.

The Opening Session

An opening session will be held on Monday, September 4, in the Engineering Societies Building, which will be presided over by President Alexander G. Christie of the A.S.M.E., and President Donald H. Sawyer of the A.S.C.E. will present greetings to which responses will be made by President William J. E. Binnie of The Institution of Civil Engineers, President E. Bruce Ball of The Institution of Mechanical Engineers, and President Harold W. McKiel, President of the E.I.C. There will also be a reception and tea in which, in addition to the officers of the five participating organizations, the Presidents of the following bodies will join: United Engineering Trustees, Engineering Foundation, American Engineering Council, Engineers' Council for Professional Development, Engineering Societies Library, American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers, Society of Automotive Engineers, Society of Naval Architects and Marine Engineers, Society of American Military Engineers.

An inspection of the Engineering Societies Library and offices of the various societies will follow and at five o'clock a tablet in memory of Calvin W. Rice, former Secretary of the A.S.M.E., will be unveiled in the lobby of the Engineering Societies Building.



Wide World

CALVIN WINSOR RICE MEMORIAL TABLET TO BE UNVEILED

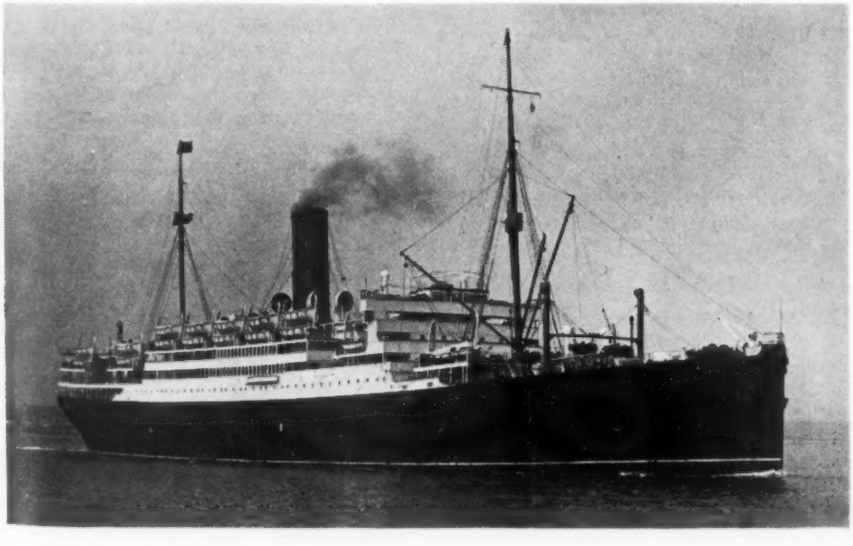
On Tuesday afternoon there will be a boat trip to show the visitors the facilities of the Port of New York. The group will leave the boat at Whitestone Landing to go to the World's Fair where the party will dine in a body.

Banquet on Wednesday Evening

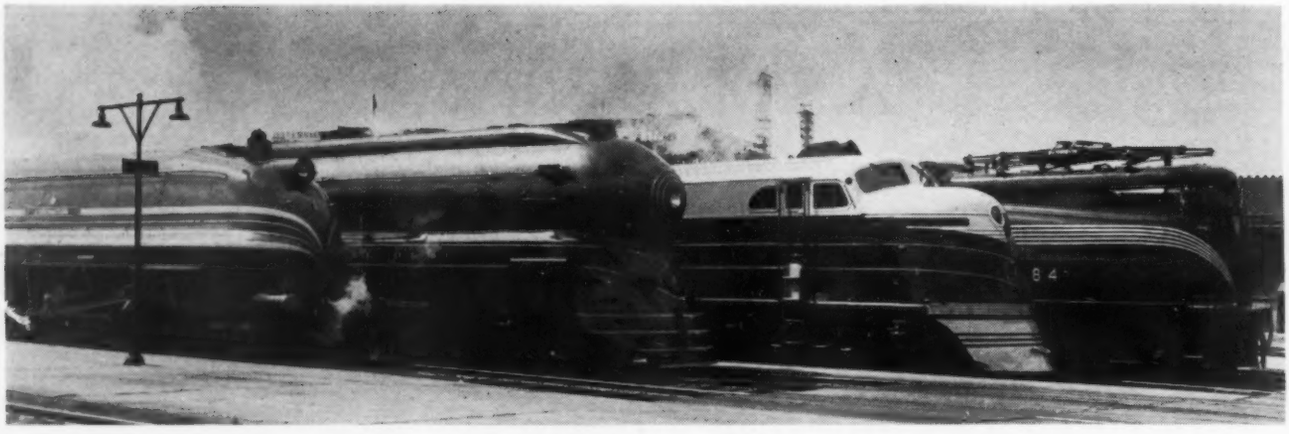
Three official representatives of Great Britain, Canada, and the United States will speak at the banquet which is to be held at the Hotel Waldorf Astoria on Wednesday evening. The Hon. Charles D. Howe, Minister of Transport, will be the speaker for Canada. Dr. Nicholas Murray Butler, President of Columbia University, will serve as toastmaster.

On Thursday evening a meeting will be held in McMillin Academic Theatre (Broadway at 116th Street) in commemoration of the 75th Anniversary of the founding of the School of Engineering of Columbia University, at which greetings will be presented from the National Societies participating in the Congress and an address will be given.

The Friday morning closing session



THE S.S. "SAMARIA" ON WHICH THE BRITISH ENGINEERS COMING TO ATTEND THE BRITISH AMERICAN ENGINEERING CONGRESS WILL CROSS



THOSE IN ATTENDANCE AT THE BRITISH AMERICAN ENGINEERING CONGRESS WILL INSPECT THE "CORONATION SCOT," BRITAIN'S LATEST LUXURY STREAMLINER OF THE LONDON, MIDLAND & SCOTTISH RAILWAY

(Standing beside three streamlined American locomotives, reading left to right: "The Coronation Scot," the "Royal Blue," the "Capitol Limited," a Baltimore & Ohio Diesel-electric locomotive, and a Pennsylvania electric locomotive.)

at the World's Fair will be presided over by President Donald H. Sawyer of the A.S.C.E. The participating societies will award honors.

Kettering to Speak at Closing Session

The address of the Friday morning occasion will be delivered by Charles F. Kettering, president, General Motors Research Corporation, who will speak on the subject "Have Engineering and Science Gone Too Far?" The closing remarks will be made by President Alexander G. Christie of the A.S.M.E. Following this closing session the party will have dinner at the Fair.

An outline of the tentative program for the Congress was published in the July issue of MECHANICAL ENGINEERING, page 563. The program of events for the women in attendance at the Congress was also given.

A circular with complete information on the Congress together with a blank for reservations for hotel accommodations and for the various events is available to members of the Society upon request to A.S.M.E. headquarters.

Diesel Engines, Lubrication Stressed at Oil and Gas Power Meeting, June 19–22

Division Is Guest of University of Michigan at Ann Arbor; Program Included Five Technical Sessions, Trip, and Banquet

DIESEL ENGINES and their lubrication were in the spotlight at the twelfth National Meeting of the Oil and Gas Power Division of The American Society of Mechanical Engineers, held at the University of Michigan Union, Ann Arbor, Mich., June 19–22, 1939, under the auspices of the Detroit Section of the Society and the University's College of Engineering. The University, in its role of host, made available to meeting participants the complete facilities of the school and the ivy-covered, red-brick Union building with its living accommodations, restaurant and cafeteria, a meeting hall, exhibit rooms, swimming pool, game room, and library. Supplementing the four-day program of five technical sessions, an inspection trip to the General Motors Diesel plant in Detroit and a banquet, individual tours were arranged for visitors through the laboratories of the engineering college and the allied science departments of physics and chemistry.

Prior to the opening technical session on Monday afternoon, June 19, more than 100 A.S.M.E. members and guests had registered; the total registration for the meeting exceeded 200. Harte Cooke, in his role of chairman at the first technical session, opened the meeting by introducing L. H. Morrison, chairman of the Division, and M. J. Reed, secretary, who fulfilled the duties of a recorder at all of the technical sessions, following which the audience heard a brief address of welcome by H. C. Anderson, dean of the college of engineering at the University.

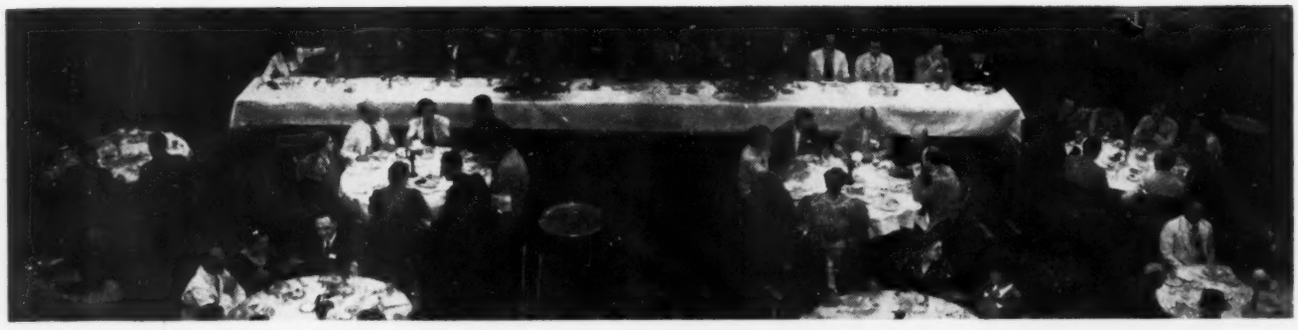
Technical Sessions

At Monday afternoon's session, two papers on developments in oil and gas engines in Europe, written especially for this meeting by A. K. Bruce, of London, England, and M. Bochet, of Paris, France, were presented in abstract form by Col. Oliver F. Allen. The third paper, written by C. G. A. Rosen and C. R. Maxwell and presented by the latter, described recent American developments in high-speed Diesel engines. The discussions at this and subsequent sessions, which were indulged in by practically everyone present, brought out many points of interest to engineers. In regard to the two European papers, it was pointed out that the development of the Diesel engine has been retarded in England because it is a coal country, but recent interruptions in the grid system and war scares have led to increased use of this type of power.

H. C. Thuerk presided at the Tuesday morning session at which Prof. P. H. Schweitzer, with the able assistance of Prof. C. W. Good, presented his paper on the analysis of the "Oil Engine Power Cost Report" through the medium of questions and answers, Professor Good doing the asking and Professor Schweitzer the explaining. E. J. Kates read a paper on the "Joint Use of Diesel Engines and Utility Power." The session in the afternoon was devoted to four papers on piston rings and cylinder wear, which were presented individually by J. M. Dodge, Paul S. Lane, D. D. Cook, and Stuart Nixon.

Chairman of the session on Wednesday morning was Lee Schneitter. Prof. Walter F. Weiland described a method he had evolved for testing the stability of crankcase oils. However, many discussers, especially those from the major oil companies, felt that the new method did not completely solve the problem on which some of them had already spent hundreds of thousands of dollars without any appreciable success. The paper on the "Operation of Lubricating Oil Systems," by Paul Williams, was presented by James H. Skinner.

TALKING IT OVER AT THE OIL AND GAS POWER MEETING



ABOUT ONE HUNDRED AND FIFTY ATTENDED THE BANQUET ON WEDNESDAY EVENING AT THE OIL AND GAS POWER MEETING

The place of the third speaker at this session, F. G. Shoemaker, was taken by Stanley B. Tuttle, one of the engineers associated with him in the development of the General Motors two-cycle Diesel engine, which was the subject of a sound-motion picture and a paper presented by Mr. Tuttle. The concluding session on Thursday morning featured a paper on ignition and combustion by Prof. H. E. Degler, which was read in his absence by Prof. C. W. Good, and others by Prof. V. L. Maleev and by Prof. E. T. Vincent.

Exhibits

The Oil and Gas Power Division conducts an exhibit by manufacturers in conjunction with its national meetings. This year, there were displayed all types of fuel distributors and injectors, centrifuges, filters, pistons, piston rings, and testing equipment. Exhibitors included the Aluminum Co. of America, American Air Filter Co., American Bosch Corp., Diesel Equipment Corp., Ex-Cell-O Corp., Fulton Sylphon Co., Hilliard Corp., Honan-Crane Co., International Harvester Co., Illinois Testing Laboratory, Koppers Co., Nathan Manufacturing Co., Wm. W. Nugent Co., Inc., Physicists Research Co., and Scintilla Magneto Co.

Women Enjoy Themselves

The program for the women was opened with a tea on Monday afternoon in the Pendleton Library of the Union. This tea offered the opportunity for a "get-together" for about 25 women, including guests from out of town and the wives of local members. Tuesday morning, the women obtained special permission to go through the University's William L. Clements Library, famous throughout the world for its collection of books on American history. Other buildings visited during the day included the elementary school, graduate school, Hill auditorium, and the law quadrangle. The afternoon was spent at the Barton Hills Country Club where the women had lunch and played bridge. Wednesday, a visit was paid to Greenfield Village at Dearborn.

G.M. Diesel Plant Inspection

Wednesday afternoon, three large busses, supplied through the courtesy of General Motors Corporation, took about 200 members and guests to the new Diesel-engine manufacturing plant of the Corporation, located at Outer Drive, Detroit, Mich. The two-cycle Diesel engines manufactured at this plant at the rate of 50 per eight-hour day were described in the March, 1938, issue of MECHANICAL ENGINEERING, page 252. Other items of interest seen by the visitors were the corporation's Diesel-engine development and design laboratory and the test and research laboratory.

Diesels Discussed at Banquet

The banquet on Wednesday evening attracted about 150 persons, including Harte Cooke and James W. Parker, vice-presidents of the Society; S. W. Smith and C. S. Yoakum, vice-presidents of the University; and Max W. Benjamin, chairman of the Detroit Section of the A.S.M.E. Ernest Nibbs, Electric Boat Co., acted as toastmaster. The guest speaker of the evening, who had come all the way from Washington, D. C., was Capt. James E. McInerney, Ordnance Department, U. S. Army. In his address, entitled "Diesels for National Defense," Captain McInerney discussed the place of the Diesel engine in naval ships, military vehicles, and aircraft, and described its use by Germany, Italy, Great Britain, and the United States up to the present time. After comparing the Diesel engine with the gasoline engine point for point, he said that if the former were in a required stage of development, this type of motive power should be in every commercial and military vehicle. This stage of development, in Captain McInerney's opinion, will be reached within a decade. Following the talk, sound-motion pictures showing the 7th Mechanized Calvary, U. S. Army, in action were shown.

Acknowledgments

Credit for the fine meeting and its smooth operation is due to the local committee whose members included C. W. Good, chairman, R. S. Hawley, J. M. Nickelsen, C. W. Spooner, H. L. Kohler, and E. T. Vincent. The program committee, consisting of Lee Schneitter, chairman, Oliver F. Allen, and C. W. Good, gathered for the meeting a most comprehensive group of papers, including two from engineers in Europe.

A word of praise is due to the women who made the stay of the visitors so enjoyable; the committee was made up of Mrs. Vera L. Good, chairlady, Mrs. O. F. Allen, Mrs. C. F. Kessler, Mrs. R. S. Hawley, Mrs. F. A. Mickle, Mrs. C. W. Spooner, and Mrs. F. N. Calhoon.

A.S.M.E., A.I.M.E., and Stevens Institute Conduct Economics Conference

OPENING the ninth annual Economics Conference, held at the Stevens Institute of Technology camp at Johnsonburg, N. J., June 24–July 3, Dr. Leverett S. Lyon, executive vice-president of the Brookings Institution, stated "We have been in the habit of thinking that economic life in America is essentially private business activity. This is by no means all the truth and it is becoming steadily less the truth." Dr. Lyons, Otto Beyer, Dr. Mordecai Ezekiel, Virgil Jordan, Judge R. V. Fletcher, Carroll Miller, Mrs. Elinor M. Herrick, Thurlow M. Gordon, John C. Gall, and Prof. Walter E. Spahr, speaking at the general evening sessions of the Conference, presented various aspects of the general theme of the ten-day meeting, "The Interrelations of Business and Government."

The Conference, sponsored jointly by Stevens, the Management Division of the A.S.M.E., and the New York section of the A.I.M.E., was attended by more than a hundred engineers, economists, and educators. The day-by-day schedule provided a total of 64 sessions. In five simultaneous series of morning lectures, of which each Conference participant could elect two, the following subjects were discussed: What will happen to the patent system? job evaluation and merit rating, industrial psychology, labor and wages, and cost analysis and control. Three of the series of lectures illustrated in one way or another the strategically important place of the engineer in the definition of employer-employee relations.

S.P.E.E. Elects Officers and Honors Timoshenko

HOLDING its 1939 annual meeting at The Pennsylvania State College, June 19–23, the Society for the Promotion of Engineering Education elected the following: O. J. Ferguson, Univ. of Nebraska, president; and R. W. Sorenson, California Institute of Technology, and D. B. Prentice, Rose Polytechnic Institute, vice-presidents, W. O. Wiley was reelected as treasurer and F. L. Bishop as secretary. It was decided to hold next year's meeting at the University of California, Berkeley, Calif., June 25–28, and the 1941 meeting

at the University of Michigan, Ann Arbor, Mich., June 23–27.

Stephen P. Timoshenko, fellow A.S.M.E., was awarded the twelfth Lamme Medal of the S.P.E.E. for "his devotion to teaching as an art; for his distinguished classroom work as a teacher; for his ability to inspire students toward ideals of scholarship and service; for his leadership in developing graduate work in mechanics, elasticity, and strength of materials; for the enthusiasm he has imparted to many disciples to go from his classroom to devote themselves to research and to teaching; and for his continuing influence on them in their development."

Keep in Mind the A.S.M.E. Photographic Exhibit in Philadelphia

Get Your Entry Form for Fourth Annual Showing

MEMBERS of the Society and their friends are invited to submit technical and nontechnical photographs for showing at the Fourth Annual A.S.M.E. Photographic Exhibit to be held during the 1939 Annual Meeting of the Society in Philadelphia, Dec. 4–8, 1939. Prints mounted on 16 × 20-in. light-colored cards should be sent, on or before Nov. 30, 1939, to the A.S.M.E. Photo Exhibit Committee, The Engineers Club, 1317 Spruce Street, Philadelphia, Pa., together with an entry fee of $1 to cover return postage, insurance, and wrapping. This year, MECHANICAL ENGINEERING will award cash prizes of $5, $3, and $2, and honorable-mention citations for all photographs selected for reproduction on the cover and in the editorial pages of the Society's journal. Official entry forms may be secured from the Committee.

"SPEED FOR MILWAUKEE ROAD"

(Photograph by E. S. Thompson shown at the Photographic Exhibit of the 1938 A.S.M.E. Annual Meeting.)

GENERAL MEETING OF PROFESSIONAL DIVISIONS CONFERENCE AT A.S.M.E. HEADQUARTERS, MAY 19, 1939, HARTE COOKE, PRESIDING

(Representatives of the 16 Professional Divisions and one Group assembled for a general discussion prior to the separate meetings held by departments in basic science, manufacturing, power, transportation, and management. Principal topics discussed were the possibility of extending the number of sessions at Annual Meetings, the rotation of executive committee members of the various Professional Divisions, ways of obtaining better papers, and the value of exhibitions at national meetings of Divisions.)

Professional Divisions Approve Junior Participation

AT A MEETING of the Professional Divisions Standing Committee in New York, June 16, with Harte Cooke presiding in the absence of Chairman L. K. Sillcox, it was voted to advise all Professional Divisions to place on the executive committee of each Division one junior member of the Society, preferably living in the neighborhood of the secretary of the Division. In this way, it is felt, the Junior member on the executive committee would be of assistance to the secretary in carrying on the activities of the Division.

Executives Form A.S.A. Advisory Committee

ACCORDING to an announcement of the American Standards Association, of which the A.S.M.E. is a member body, the following executives of industry, education, and finance, have accepted invitations to form an Advisory Committee which will aid the Association in broadening its work: Howard Coonley, member A.S.M.E., and chairman of board, Walworth Company, *chairman;* Ralph Budd, president, Burlington Lines; Floyd L. Carlisle, chairman of board, Consolidated Edison Company of New York; Dr. Karl T. Compton, member A.S.M.E., and president of M.I.T.; Lammot du Pont, president, E. I. du Pont de Nemours & Company; Lincoln Filene, president, Wm. Filene's Sons Company; Walter S. Gifford, president, A.T.&T.; Leroy A. Lincoln, president, Metropolitan Life Insurance Company; J. H. McGraw, Jr., member A.S.M.E., and president, McGraw-Hill Publishing Co., Inc.; A. W. Robertson, member A.S.M.E., and chairman of board, Westinghouse Elec. & Mfg. Co.; Alfred P. Sloan, Jr., chairman of board, General Motors Company; E. R. Stettinius, Jr., chairman of board, U. S. Steel Corporation; and Walter C. Teagle, chairman of board, Standard Oil Company of New Jersey.

Hydraulic Division to Take Part in Hydrologic Union Meeting, Sept. 15–16, 1939

ONE of the participating bodies in the International Hydrologic Union meeting in Washington, D. C., during the week ending Sept. 16, 1939, will be the Hydraulic Division of the A.S.M.E. According to preliminary announcements, the Division may sponsor several sessions on Friday, Sept. 15, on water hammer and water measurement. On Saturday, Sept. 16, meeting participants and interested A.S.M.E. members have been invited by the Pennsylvania Water & Power Company to its Holtwood plant for the purpose of making full-scale demonstrations of the measurement of water in a pipe line.

Blackstone

Warren H. McBryde

Nominated for President

A.S.M.E. OFFICERS *Nominated for* 1939-1940

MEMBERS of The American Society of Mechanical Engineers through their representatives on the 1939 Regular Nominating Committee, which met at State College, Pa., June 16–17, nominated Warren H. McBryde, consulting engineer of San Francisco, Calif., for the office of President of the Society in 1940.

Vice-Presidents nominated by the Committee to serve on the Council of the Society were Kenneth H. Condit, New York, N. Y., Francis Hodgkinson, New York, N. Y., J. C. Hunsaker, Boston, Mass., and K. M. Irwin, Philadelphia, Pa.

The Committee's nominations for members of the Council to serve as managers were J. W. Eshelman, Birmingham, Ala., Linn Helander, Manhattan, Kan., and G. T. Shoemaker, Chicago, Ill.

Members of the Committee who were in attendance at State College, Pa., and made the nominations were: W. L. Edel, Storrs, Conn., chairman; T. Baumeister, Jr., New York, N. Y.; B. F. Rogers, Kingston, Pa., secretary; Blake R. Van Leer, Raleigh, N. C.; F. C. Hockema, Lafayette, Ind.; F. J. Holzbaur, Sugar Creek, Mo.; and E. B. Parker, Pullman, Wash.

Election of A.S.M.E. officers for 1940 will be held by letter ballot of the entire membership, closing on Sept. 26, 1939.

Biographical sketches of the nominees follow on the succeeding pages:

Warren H. McBryde

WARREN HORTON McBRYDE, consulting engineer, industrialist, and world traveler, of San Francisco, Calif., who has been nominated for the office of President of The American Society of Mechanical Engineers, was born at Mobile, Ala., in 1876. At the age of 17, he entered the Alabama Polytechnic Institute, Auburn, where he specialized in electrical and in mechanical engineering. He was graduated in 1897 with the degree of B.S.

Immediately after graduation, he was employed by the Mobile Light & Railroad Co., following which he did architectural designing and drafting for George F. Barber & Co., Knoxville, Tenn. During the Spanish-American War, he served for a few months in the U. S. Lighthouse Department and had charge of the submarine mines, searchlights, and electrical equipment guarding the entrance to Mobile Bay. Following this he was made chief electrician of the U. S. Army Transport *Sheridan*, on which he made a voyage from New York, N. Y., via the Suez Canal, the Philippines, and Nagasaki, Japan, to San Francisco, where he was honorably discharged. From 1899 to 1903, Mr. McBryde was employed by the Yuba Electric Power Company as assistant resident engineer in charge of construction on the Colgate hydroelectric powerhouse, by the Peyton Chemical Company, San Francisco, and by the Bay Counties Power Company, also of San Francisco, as chief draftsman and assistant to the chief electrical and mechanical engineer.

He was resident engineer in charge of construction at Gibbstown, N. J., for the E. I. du Pont de Nemours Powder Company from 1903 to 1905, and was transferred during the year 1905 to Hercules, Calif. In 1906, he was appointed chief of the West Coast engineering and construction department of the du Pont organization and, subsequently, became assistant superintendent of its Hercules plant. When, in 1912, as a result of the suit by the government against the E. I. du Pont de Nemours Powder Company, the Hercules Powder Company was formed to take over this and a number of other plants and a portion of the business of the du Pont Company, he retained this position and remained with the new company until 1919. During this period, Mr. McBryde was in charge of all maintenance and repairs, and handled many important engineering problems in connection with the hurried construction of 12 large TNT plants, the necessary nitric- and sulphuric-acid factories, and many other industrial buildings during the World War. He was also in charge of the labor- and industrial-relations department of the company and, with the help of the employment manager, secured positions for more than three quarters of the 4000 men under his supervision when demobilization came.

In 1919, he became secretary and assistant to the general manager, California & Hawaiian Sugar Refining Co., San Francisco, and handled many varied engineering problems for the company until 1927, when he engaged on his own account in his present business as a consulting engineer.

Mr. McBryde was elected a member of the Society in 1921. He was chairman of the San Francisco Section in 1925 and 1926, when the Spring Meeting was held in San Francisco in the latter year. As a delegate from the Section, he attended the 1926 Annual Meeting of the Society in New York, N. Y., and the celebration at Washington, D. C., in 1931, of the fiftieth anniversary of the formation of the A.S.M.E.

In company with Calvin W. Rice, Mr. McBryde represented the Society at the 75th anniversary of the Verein deutscher Ingenieure at Cologne, Germany, in June, 1931; he also attended the 1931 and 1935 spring meetings in England of The Institution of Mechanical Engineers at Cambridge and Bath, respectively. He was one of the founders of the Engineering Societies Employment Service office in San Francisco. In 1937, Mr. McBryde was elected vice-president of the A.S.M.E. and in his official capacity attended the 1937 and 1938 Annual Meetings in New York City. He has taken a great deal of interest in the activities of A.S.M.E. student members and has attended their meetings at several schools on the West Coast as well as the Student Group Meetings, in 1937 and 1938, at Los Angeles and San Francisco, respectively. His knowledge of European affairs has been greatly increased as a result of motor trips through Central Europe during the summers of 1937 and 1938, and a visit during December, 1937, and January, 1938.

Other activities of Mr. McBryde include election as mayor of Hercules, Calif., and supervisor of Contra Costa County, while a resident of that city; the San Francisco Engineers' Club; the San Francisco Electrical Development League; and the presidency of the Industrial Association of San Francisco, in 1921, in recognition of his experience as an industrial employer and his interest in workingmen.

For Vice-Presidents

Kenneth H. Condit

KENNETH HAMILTON CONDIT, who has been nominated for the office of Vice-President of The American Society of Mechanical Engineers, is executive assistant to the president, The Conference Board, New York, N. Y. Mr. Condit is just completing a term of service as Manager of the Society to which position he was elected in 1936. From 1923 to 1928, he served on the Committee on Publications, from 1928 to 1933, on the Committee on Awards, and from 1933 to 1936, on the Committee on Professional Divisions. He has also served as Council member on the Society's Finance Committee and as Senior Councilor of Local Sections Group II.

Mr. Condit was born at East Orange, N. J., on March 1, 1888. He was educated in the schools of that town and was graduated from Stevens Institute of Technology in 1908 with the degree of mechanical engineer. He commenced his engineering work in the Safety Car Heating & Lighting Co., as a draftsman and assistant engineer. Ill-health made desirable a change to work that would provide more outdoor employment, so Mr. Condit, in 1910, accepted a position with the Newark branch of A. G. Spalding & Bros., at that time agents for the Stevens Duryea automobile, and later with the White Motor Co., in order to become familiar with motor-truck problems.

In 1911 it became possible for Mr. Condit to renew his educational career by taking courses in civil engineering at Columbia University, where he spent one term, and at Princeton, where he received the degree of civil engineer in 1913.

As the result of the offer of an instructorship in engineering at Princeton, Mr. Condit continued at the University from 1913 to 1917 in charge of the materials-testing laboratory and engaged in teaching a number of engineering subjects. On July 5, 1917, he was commissioned as a first lieutenant in the aviation section of the U. S. Army Signal Corps. With two other members of the Princeton faculty he organized the Princeton School of Military Aeronautics and was placed in charge of the engine department. In September, 1918, he was promoted to a captaincy and transferred to Wright Field, Dayton, where he remained until after the Armistice.

Mr. Condit became associate editor of *American Machinist* in January, 1919. He was made managing editor late in December of the same year, and became editor in 1920, continuing in that position until 1938 when he was made consulting editor at the time of his transfer to The Conference Board. In 1929, he started *Product Engineering*, serving as editor until 1935 when he became consulting editor. He is consulting editor of the McGraw-Hill Book Co., Inc., Product Development Series.

He joined the A.S.M.E. in 1921 and has been actively engaged in its activities ever since. In addition to his periods of service on administrative committees, Mr. Condit served the Machine Shop Practice Division as its secretary in 1923, and as a member of its executive committees several years later.

He is a member of the A.S.A. Sectional Committee on Scientific and Engineering Symbols and Abbreviations; Special A.S.A. Committee on Preferred Numbers; and advisory member of the Special Research Committee on Cutting of Metals, Subcommittee on Metal Cutting Data. Mr. Condit is one of the A.S.M.E. representatives on the Board of the United Engineering Trustees and one of the representatives of the U.E.T. on the Engineering Foundation Board. He is a member of both the Executive Committee and of the Research Procedure Committee of the Foundation board.

He has served as secretary and president of the Princeton Engineering Association and is now chairman of its Committee on Education. He is now vice-president of the Princeton Geological Association. Mr. Condit has also served as secretary of the National Conference of Business Paper Editors, and as a member of the Mechanical Advisory Board of the Museum of Science and Industry, New York, N. Y.

Wide World

K. H. CONDIT

Blackstone

FRANCIS HODGKINSON

J. C. HUNSAKER

Phillips

K. M. IRWIN

Nominated for Vice-Presidents

Francis Hodgkinson

FRANCIS HODGKINSON, nominee for the office of Vice-President of The American Society of Mechanical Engineers, is honorary professor of mechanical engineering at Columbia University, New York, N. Y., and retired consulting mechanical engineer of the Westinghouse Electric & Manufacturing Co. He was born in London, England, on June 16, 1867, and educated at the Royal Naval School at New Cross, at the Department of Science and Art at New Kensington, and Rutherford College of Durham University, Newcastle-on-Tyne, England; courses at the last two schools being pursued in the evening. From 1882–1885, Mr. Hodgkinson served as an apprentice with Clayton & Shuttleworth, of Lincoln, builders of agricultural machinery, and steam engines. From 1885 to 1889, he was employed by Clarke, Chapman, Parsons & Co., builders of ship auxiliaries, including small turbine-electric generating sets. It was here that the earliest Parsons steam turbines were built. In 1889, a dissolution of the partnership brought about the incorporation of C. A. Parsons & Co., where he was progressively machinist, draftsman, and superintendent of field construction, principally of Parsons steam turbines.

In 1890, he accepted an appointment as an engineer officer in the Chilean Navy in which he saw action during the Chilean Revolution. From 1891 to 1892, he was associated with Percy Burbank, consulting engineer, of Lima, Peru, and representative of the Thomson-Houston Co., in the operation of a small public-utility plant and installation of electric-lighting plants, telephones, etc. Then, in 1892, he worked as a master mechanic in the ore-smelting and concentrating plant of a silver and copper mining company located at an elevation of 14,000 ft in Cordillera, Peru.

Returning to England in 1894, he was made shop superintendent of his old company, C. A. Parsons & Co., where he had an opportunity later on to design steam turbines under the direction of Sir Charles Parsons. Upon the Westinghouse Machine Co's acquiring a license in 1895 for the construction and sale of Parsons steam turbines in the United States, Mr. Hodgkinson was sent to this country by the Parsons Company in 1896 to direct the design and construction of steam turbines. He remained with the Westinghouse Machine Co., which later became the machine works of the Westinghouse Electric & Manufacturing Co., organized its turbine department, and became chief engineer in 1916. In 1926, he was appointed consulting mechanical engineer of the company, which position he held until 1936 when he was retired upon reaching the retirement age.

Since joining the Society in 1902, Mr. Hodgkinson has taken an active part in the work of many committees, having been chairman of the Main Committee on Power Test Codes and P.T.C. Subcommittee No. 20 on Speed Responsive Governors, and member of P.T.C. Subcommittee No. 6 on Steam Turbines. As A.S.M.E. representative on the International Electrotechnical Commission, United States National Committee, he has served as chairman of the Special Committee on Steam Turbines and of the Special Committee on Internal-Combustion Engines. Another function with the I.E.C. has been his acting as director of the secretariats of the Advisory Committees on Steam Turbines and on Internal-Combustion Engines.

Mr. Hodgkinson also holds membership in the Engineers Society of Western Pennsylvania, Newcomen Society, and The Institution of Mechanical Engineers (Great Britain). He is an associate of the American Institute of Electrical Engineers. His genius as a designer, inventor, and constructor of steam turbines has been recognized throughout the world as is evidenced by his being awarded the Silver Medal of the Louisiana Purchase Exposition in 1904, the Elliot Cresson Gold Medal of The Franklin Institute in 1925, the honorary degree of M.E. from Stevens Institute of Technology in 1935, the Willans Gold Medal of The Institution of Mechanical Engineers (Great Britain) in 1937, and the Holley Medal of the A.S.M.E. in 1938.

J. C. Hunsaker

JEROME CLARKE HUNSAKER, aeronautical engineer and educator, who has been nominated for the office of Vice-President of The American Society of Mechanical Engineers, was born in Creston, Iowa, Aug. 26, 1886. He was graduated from the U. S. Naval Academy, Annapolis, Md., in 1908, and commissioned as an officer in the Construction Corps, U. S. Navy. As part of the naval policy of giving officers as broad a training as possible, he was permitted to take graduate studies at the Massachusetts Institute of Technology, receiving the degrees of M.S. in 1912, and D.Sc. in 1916.

From 1912 to 1916, he was assigned to M.I.T. as an instructor in aeronautical engineering. Then, from 1916 to 1923, during which time he was advanced to the grade of commander, he was put in charge of aircraft design at the U. S. Navy Department in Washington, D. C. It was during this period that he designed the airship *U.S.S.Shenandoah*, and the flying boat *NC4*, first aircraft to fly the Atlantic Ocean. Commander Hunsaker was assigned as an assistant naval attaché, from 1923 to 1926, to the American embassies in London, Paris, Berlin, and Rome.

In 1926, he retired from the Navy to accept a position as an assistant vice-president of the Bell Telephone Laboratories, where he developed wire and radio services for the airways of America. As vice-president of the Goodyear Zeppelin Corporation from 1928 to 1933, he helped to design and build the airship *U.S.S. Akron*. Since 1933, he has been head of the department of mechanical engineering at M.I.T. and, also, professor in charge of the school's Guggenheim aeronautical laboratory.

Commander Hunsaker was elected to membership in the Society in 1933, and has been secretary of the Applied Mechanics Division. He is chairman of Subcommittee No. 7 on Aeronautical Symbols, Committee on Letter Symbols and Abbreviations for Science and Engineering.

Other scientific and technical affiliations include membership in the National Academy of Sciences and National Advisory Committee for Aeronautics; he is a fellow of the American Physical Society and of the American Academy of Arts and Sciences; an honorary fellow of both the Institute of Aeronautical Sciences and the Royal Aeronautic Society of Great Britain and a member of the American Society of Naval Architects, Society of Automotive Engineers, and Sigma Xi.

For his contributions to the science of aerodynamics, to the science and art of aircraft design, and to the practical construction and commercial utilization of rigid airships, Commander Hunsaker was awarded the Daniel

Mercer Wilson

J. W. ESHELMAN

LINN HELANDER

G. T. SHOEMAKER

Nominated for Managers

Guggenheim Medal in 1933 by a board consisting of members of the A.S.M.E., S.A.E., and I.A.S. He is also the recipient of the U. S. Navy Cross.

K. M. Irwin

KILSHAW McHENRY IRWIN, nominated as a candidate for Vice-President of The American Society of Mechanical Engineers, is assistant to the vice-president in charge of engineering, Philadelphia Electric Company. Born in Waukeesha, Wis., he was educated at Phillips Academy and Sheffield Scientific School of Yale University, from which he received the degree of Ph.B. in 1915.

He started his engineering career as a test engineer with B. F. Sturtevant Company, at Hyde Park, Mass., in 1915. In 1916 and 1917, he was a member of the station betterment division, Stone & Webster Engineering Corporation, Boston, Mass. His practice in 1918 as a consulting fuel engineer, in Boston, was interrupted by the World War and his enlistment as chief machinist's mate in the U. S. Navy. From 1919 to 1931, he held the position of mechanical engineer with the United Gas Improvement Company. Since 1931, he had been assistant to the vice-president in charge of engineering, Philadelphia Electric Company. In his present position, Mr. Irwin has been directly responsible for the mechanical design of Barbadoes Island power station, Philadelphia Electric Co.; Devon power station, Connecticut Light & Power Co.; Big Sioux power station, Sioux City Gas & Electric Co.; and Deepwater power station, Deepwater Light & Power Co. He has described his work on these and other projects in numerous articles appearing in scientific and technical journals.

Mr. Irwin was elected to membership in the Society in 1917, and has served as chairman of the Fuels Division, 1934–1936; member of the Regular Nominating Committee, 1934; chairman of the Finance Committee, 1937–1939; and chairman of the Philadelphia Section, 1930–1931. Beside representing the A.S.M.E. he is also chairman of the Committee to Cooperate with Consumer's Council with relation to activities of National Bituminous Coal Commission.

Other engineering activities include membership on the Prime Movers Committee, N.E.L.A., 1922–1931; A.E.I.C. Committee on Power Generation, 1939; United States Committees on Steam Turbines and Diesel Engines, International Electrotechnical Commission Conference in Holland and Belgium, 1935; and the presidency of the Philadelphia Engineers Club, 1936–1937.

For Managers

J. W. Eshelman

JOSEPH WILLIAM ESHELMAN, who has been nominated for the office of Manager of The American Society of Mechanical Engineers, was born in Greencastle, Pa., Jan. 31, 1893. His present residence is in Birmingham, Ala., where he has been located since 1921.

He attended the Pennsylvania State Normal School, Shippensburg, Pa., and was graduated with honors in 1911. After graduation, he spent a year with the Railway Mail Service. In 1912, he was employed in the engineering department of the Bell Telephone Company of Pennsylvania. The next several years were spent in Wyoming and Oregon, where he was associated with one of the large banks in connection with its mining and lumbering interests, and also spent much time in various educational activities.

In 1917, Mr. Eshelman specialized in combustion-engineering and fuel-conservation problems in the Midwest. From 1918 to 1920, he was associated with the Republic Flow Meters Company in a sales-engineering capacity at Chicago, New York, and Pittsburgh. Then, in 1920, he was made Southern manager of the company, having charge of sales in the South East. He served in this position until 1926 when he established his own sales-engineering business, which is known today as Eshelman & Potter, and of which he is president.

He was elected to associate membership in the Society in 1926. He has served as chairman of the Birmingham Section, was Local Sections delegate for two years, and has been active in the student-branch movement and Junior-engineer development and advancement. He is also a member of the Association of Iron & Steel Engineers and Birmingham Engineers Club, and a registered professional engineer in the State of Alabama.

Linn Helander

LINN HELANDER, nominated for the office of Manager of The American Society of Mechanical Engineers, is professor of mechanical engineering and head of the department of mechanical engineering at Kansas State College. He was born in Chicago, Ill., Aug. 28, 1891, and graduated from the Yeatman High School in St. Louis, in 1910, and from the University of Illinois in 1915 with the degree of B.S. in mechanical engineering.

For a brief period after graduation, Professor Helander worked as a member of a group investigating stresses in railroad rails under the direction of Prof. A. N. Talbot, and then entered the employ of the Pittsburgh Crucible Steel Company, Midland, Pa., as a steam engineer. From 1917 to 1918 he was on the editorial staff of *Iron Age*, and from 1918 to 1919 was assistant engineer of tests, Ordnance Department, U. S. Army, with supervisory responsibilities in the Montreal District. In 1919 he became a general engineer with the Westinghouse Electric & Manufacturing Co., where he made extensive studies in the use of regenerative feedwater heating, higher pressures and temperatures, and reheating.

From 1925 to 1929, Professor Helander was a senior engineer with the U.G.I. Contracting Company, Philadelphia, Pa., now United Engineers and Constructors, and from 1929 to 1931 was employed first by the Westinghouse Company on a special assignment, and then by the Champion Fibre Company, as a consultant. In 1931, he became assistant professor of mechanical engineering at the University of Pittsburgh, and in 1935 was appointed to his present position of professor and head of the department of mechanical engineering at Kansas State College. From 1933 to 1935, he was engaged in private practice in Chicago as a consulting and research engineer.

Professor Helander joined the A.S.M.E. as a junior in 1916 and became a full member in 1924. He is a member of The Franklin In-

titute, A.A.A.S., American Association of Political and Social Science, Kansas Engineering Society, Engineers' Club of Kansas City, Society for the Promotion of Engineering Education, Sigma Xi, Tau Beta Pi, Phi Kappa Phi, and Pi Tau Sigma. Since 1935, Professor Helander has been a member of the executive committee of the Kansas City Section, and served as vice-chairman of the Section for the fiscal year of 1936–1937 and as chairman for 1937–1938. From 1936 to 1938, he was honorary chairman of the Kansas State College Student Branch of the A.S.M.E. In 1936, he served as a delegate from Kansas State College to the Third World Power Conference, Washington, D. C.

Professor Helander has contributed widely to the technical literature on subjects related to economic and thermodynamic factors in steam-power generation. His paper on "Feedwater Heating for Higher Thermal Efficiency," given before the Society in 1922, was the first presented in this country on regenerative feedwater heating for modern steam-power plants.

G. T. Shoemaker

GUY T. SHOEMAKER, nominee for the office of Manager of The American Society of Mechanical Engineers, was born in Geneva, Ind., on Nov. 22, 1886. He attended Purdue University from which he received the degree of B.S. in electrical engineering, in 1910, and the E.E. degree in 1916. His first job was with the General Electric Company, Fort Wayne, Ind., as a student apprentice. From 1911 to 1913, he worked for the Grand Rapids Motor Truck Company, where he was in charge of general and special pattern design, and routing of work through the factory.

In 1913, he joined his present organization, The United Light and Power Company system, as a draftsman, later advancing to the positions of electrical and mechanical engineer, vice-president of the service company, vice-president and director of The United Light and Power Company, The United Light and Railways Company, and Continental Gas & Electric Corporation, and officer of several subsidiary companies. Since Aug. 1, 1938, Mr. Shoemaker has been president of The United Light and Power Service Company and in direct charge of all engineering, construction work, and operation of subsidiary companies of the holding companies. A few of the projects which he has handled include power plants at Kansas City, Mo., La Porte, Ind., Moline, Ill., Fort Dodge, Ia., Riverside station in Davenport, Ia., and Columbus, O., distribution systems in the Midwest, railway substations, and heating plants. Articles by him describing these have appeared in *Power*, *Electrical World*, and other technical publications.

Mr. Shoemaker became a member of the A.S.M.E. in 1926, and, immediately took an active part in the work of the Tri-Cities Section, serving on the Section's executive committee for many years as a member and, finally in 1933, as vice-chairman. He is also a member of the A.I.E.E., the Power Generation Committee of the Association of Edison Illuminating Companies, and the Prime Movers Committee and the Operating Committee of the Edison Electric Institute.

A.S.M.E. Executive Committee Meets

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at the Society headquarters on June 16. A. G. Christie presided, and there were present Kenneth H. Condit, Harte Cooke, Clarke Freeman, and James W. Parker, of the committee; K. M. Irwin (Finance) and D. B. Prentice (Local Sections); W. D. Ennis, treasurer; and C. E. Davies, secretary. The following actions were of general interest:

Management Division

Upon recommendation of the Management Division, approved by the Committee on Professional Divisions, cooperation was authorized between the division and the American Management Association in a management conference to be held in New York during September, 1939. L. P. Alford and L. C. Morrow will represent the Society on the program committee.

Approval was also voted of a statement of the purpose and scope of the A.S.M.E. Management Division. A statement of these objectives appeared in July, page 561.

Local Sections

For the Committee on Membership Development Mr. Prentice presented a proposed program which was approved.

Tulsa Office

It was reported that L. G. E. Bignell has been retained to replace J. H. Engelbrecht, resigned, as Mid-Continent Secretary of the Society, serving the Petroleum Division and the Sections in the Mid-Continent area.

Rutgers Conference

Approval was voted of participation by the Junior Group of the Metropolitan Section as cosponsor of afternoon and evening sessions of the Fourteenth Annual Industrial Conference of Rutgers University, Sept. 7, 1939. The main topic of the conference will be "Orientation and Training of Young College Graduates in Industry," with a subtopic "The Young College Graduate Considers His Objectives and Problems."

Oliver Evans Memorial

Approval was voted of the appointment of a committee to investigate the possibilities of the erection of a suitable memorial to Oliver Evans, pioneer American engineer, who is buried in an unmarked grave in New York City.

George Westinghouse Memoranda

The Secretary reported that through the kindness of Charles F. Scott, the Society had been presented with an original handwritten memorandum by George Westinghouse prepared on the occasion of the celebration of Dr. Rossiter W. Raymond's birthday in 1910. This will be added to the Society memorabilia.

Appointments

A. G. Christie was appointed one of four representatives of the Society on the John Fritz Medal Board of Award to serve for four years.

F. J. Holzbaur's appointment to serve as alternate for Group VII on the Nominating Committee, to replace Linn Helander, was approved.

The following additional appointments were reported:

Library, E. F. Church, Jr. (reappointment, 4-year term); Sectional Committees, Specifications for Testing Purposes, R. M. Hardgrove; and Loading Platforms at Freight Terminals and Warehouses, M. C. Maxwell; Special Research Committee on Rolling of Steel (Plasticity), John H. Hitchcock, W. Trinks, and G. B. Karelitz; P.T.C. Committee No. 13 on refrigerating systems, Walter Jones and Frank Zumbro; Engineering Foundation, A. A. Potter (4-year term); Catholic University of America, Washington, D. C., Semi-Centennial Celebration, Nov. 11–13, 1939, A. G. Christie; University of Texas, Austin, Tex., Inauguration of President, Dr. Homer Price Rainey, Nov. 18, 1939, E. W. Burbank.

A.S.M.E. Calendar

of Coming Meetings

September 4–8, 1939
Fall Meeting
New York, N. Y.

October 5–7, 1939
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions, Columbus, Ohio

October 5, 1939
Machine Shop Practice Division to hold "A.S.M.E. Day" at Machine Tool Congress, Cleveland, Ohio

October 12–13, 1939
Wood Industries Division
Boston, Mass.

November 2–4, 1939
Joint Meeting with American Institute of Physics in a Symposium on Temperature Measurement, New York, N. Y.

December 4–8, 1939
Annual Meeting
Philadelphia, Pa.

(*For coming meetings of other organizations see page 16 of the advertising section of this issue*)

A.S.M.E. to Be Represented at Engineering Examiners' Meeting

REPRESENTING the Society at the annual meeting of the National Council of State Boards of Engineering Examiners being held in San Francisco, Calif., July 26–29, are Prof. S. H. Graf, Oregon State College, Corvallis, Ore., and Prof. C. F. Scott, Yale University, New Haven, Conn.

San Francisco Section Is Host at 1939 Semi-Annual Meeting

Technical Sessions Capped by Brillant Banquet; Hoover Addresses Engineers at Fair

WITH the slogan "Greater Service to Science, Industry, and Humanity" as its theme, the 1939 A.S.M.E. Semi-Annual Meeting at San Francisco made an impressive showing as it opened its first day of technical sessions Tuesday, July 11, with a registration which exceeded 500 by Wednesday morning.

On Monday at the Hotel Fairmont, official headquarters for the meeting, the spacious lobby was the scene of many reunions: Dean Dexter S. Kimball busily greeting his old San Francisco friends and recalling the long-gone days when he helped build the famous battleship *Oregon* at the old Union Iron Works; the irrepressible Harte Cooke finding two life members, G. F. Waddell of San Francisco and the "one and only" Elmer H. Neff of New York, the combined membership tenure of the three being 125 years; and past-presidents Harvey N. Davis, William F. Durand, and Dexter S. Kimball, hobnobbing with president Alexander G. Christie and presidential nominee Warren H. McBryde.

Council and Business Meetings

The Council held an all-day session on Monday, July 10, and an evening session on July 12 at which members of the Society were particularly invited to be present. Of the 22 members of the Council, 15 were present at the Monday session and 14 at the Wednesday evening session.

The budget for the year beginning October 1, 1939, was adopted as it appears on page 635 of this issue.

Members of the Council, senior in service in each of the seven geographical areas of the country, are designated as Senior Councilors for their respective areas. Each presented detailed reports of contacts with the Sections and Student Branches during the period since the meeting of the Council in New Orleans in February.

Nine transfers from Member to Fellow grade were considered and referred to letter ballot of the Council closing July 31, 1939.

Amendments to the Constitution to bring it up to date in connection with the provisions for the Annual Meeting were approved for recommendation to the Business Session held on the afternoon of July 10.

In the administration of research projects, the relationship between the Society and the research worker frequently presents a number of problems. During the last three years the Standing Committee on Research devoted a great deal of attention to this question and prepared a model form of contract between the Society, the research agency, and the research worker which the Council adopted.

Upon petition from 25 members of the Society in Fort Wayne, Ind., and with the recommendation of the Standing Committee on Local Sections, the Council authorized the establishment of the Fort Wayne Section of the Society.

At the request of President McClellan of the American Engineering Council, the Council voted to authorize the appointment of representatives to serve with representatives of other societies in a study of the future organization and field of activity of the American Engineering Council.

In regard to the Parker case, the President reported that on June 19, the Court of Appeals affirmed the judgment entered in the Supreme Court, New York County, on the decision of the Appellate Division. On June 30, the President sent a letter to the members informing them of this fact and transmitting the unanimous opinion of the Appellate Division and the resulting judgment.

At the Semi-Annual Business Session of the Society, called to order by President Christie at 4:00 p.m., July 10, 1939, in the Red Room of the Fairmont Hotel at San Francisco, announcement was made of the coming Annual Meeting in Philadelphia during the week of December 4, 1939, and the Semi-Annual Meeting in Milwaukee, Wis., June 17–21, 1940.

The following amendments to the Constitution of the Society were proposed by 22 voting members of the Society in good standing:

Article C 7, Sec. 3: Election of Directors:

Present wording:

"The Directors shall be elected at the Annual Meeting of the Society on the first Tuesday in December, as provided in the Charter."

Proposed amendment:

"Directors shall be elected annually by sealed letter ballot of the membership."

Article C 9, Sec. 1: Meetings of the Society:

Present wording:

"The Annual Meeting of the Society shall be held at such time and place as the Council shall appoint, provided it begins in the City of New York and continues there during the annual election of directors, held on the first Tuesday in December."

Proposed amendment:

"The Annual Meeting of the Society shall be held at such time and place as the Council shall appoint."

The purpose of these amendments is to bring the situation in line with present practice and with provisions of the Membership Corporation Laws of the State of New York.

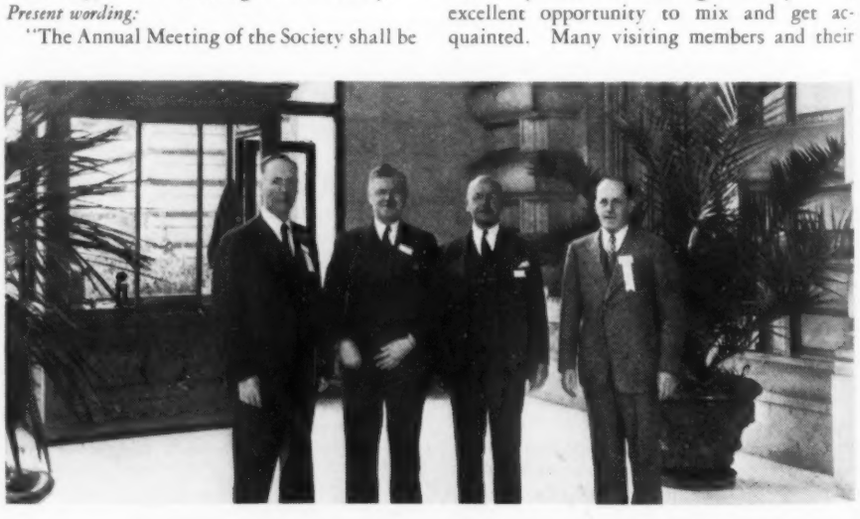
The Business Session voted to refer these amendments to letter ballot of the membership in accord with the provisions of the Constitution.

The President reported that the Court of Appeals, in a decision on June 19, 1939, affirmed the judgment of the Appellate Division which dismissed all the charges brought by John Clinton Parker and his associates, and vindicated all of the former members of the Council. The President also pointed out that no resolution had been passed by the Society, the Council, or its Executive Committee by which an assessment would be levied upon the members of the Society.

Lieutenant Davis, U. S. Navy, a member of the San Francisco Section, invited the members to visit the vessels of the naval fleet anchored in San Francisco Bay for the entire time of the meeting. He suggested that on arrival aboard any vessel the engineers should ask for the engineering officer on duty and introduce themselves. They would then be shown the entire ship as an engineer should see it and not just the surface appearance as shown to the ordinary visitor. This courtesy was much appreciated.

Varied Attractions for Ladies

Monday afternoon the Ladies' Committee entertained at tea in the Laurel Court of the hotel for visiting ladies and their escorts. This event proved the M.E.'s to be great tea tipplers as there were at least three escorts for each lady. This function gave everyone an excellent opportunity to mix and get acquainted. Many visiting members and their



AT THE A.S.M.E. SEMI-ANNUAL MEETING IN SAN FRANCISCO

(George Sullivan, Chairman of the Registration Committee; C. E. Davies, Secretary, A.S.M.E.; E. M. Breed, Chairman of the General Committee; and G. H. Raitt, Chairman of the A.S.M.E. Local Section in San Francisco.)

A.S.M.E. GROUP ON WAY TO SEMI-ANNUAL MEETING AT SAN FRANCISCO STOP OVER AT BOULDER DAM, JULY 5

ladies apparently took advantage of Monday afternoon and evening to explore the shops of San Francisco or to attend the Golden Gate International Exposition at Treasure Island.

The technical sessions, both morning and afternoon, on Tuesday, drew good audiences. The average was from 35 to 50 in each of four sessions in the morning and from 40 to 50 at each of the three sessions in the afternoon.

Banquet a Great Success

The semi-annual banquet of the society, held in the Gold Ball Room of the Fairmont Hotel, was an unqualified success, for which Chairman W. Harry Archer and his associates on the Banquet Committee deserve great praise. The Gold Ball Room forms a very fine setting for such a function. It had been especially decorated for this occasion by one of San Francisco's internationally famous florists and there were many exclamations of rapture from feminine throats over the magnificent display of gladioli, button dahlias, and tuberous begonias. The occasion was all the more delightful in that formality was confined to the speaker's table.

Chairman George H. Raitt of the San Francisco local section, in a few well-chosen words, welcomed the national officers and guests and turned over the gavel to Everett M. Breed, chairman of the General Committee on Arrangements. Mr. Breed, in turn, briefly introduced as toastmaster for the evening that grand veteran of the A.S.M.E. and of Pacific Coast engineering, past-president William F. Durand. As toastmaster Dr. Durand has few equals. He first called on President Alexander G. Christie to make an announcement, which proved to be a reading of the nomination slate for officers for the coming year. This announcement was read in reverse, culminating in the announcement of San Francisco's Warren H. McBryde as nominee for president. Mr. McBryde received a great hand and was called to the "mike" for a speech in which he vowed his purpose of serving the society to the best of his ability if elected.

The toastmaster next called on past-president Harvey N. Davis to carry out the annual ceremony connected with the Calvin W. Rice lecture. Dr. Davis, with considerable emotion referred to the career of Dr. Rice as secretary of A.S.M.E. for 31 years, and to the establishment of this annual lecture as a memorial to his services and as an effort to continue his work in international relations, and then

ESTIMATED BUDGET FOR 1939–1940 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, JULY 10, 1939

Activity	Expense under committee supervision	Printing and distribution	Direct office expense	Total
Council	$ 5,000.00	.....	.....	$ 5,000.00
Library	9,207.00	.....	.....	9,207.00
A.E.C.	8,300.00	.....	.....	8,300.00
Finance Committee	115.00	.....	.....	115.00
Awards	515.00	.....	$ 301.60	816.60
Nominating Committee	475.00	.....	.....	475.00
Local Sections	22,900.00	.....	7,787.00	30,687.00
Meetings and Program	6,400.00	.....	4,393.76	10,793.76
Professional Divisions	2,700.00	.....	4,393.76	7,093.76
Admissions	.....	.....	6,772.62	6,772.62
Employment Service	2,645.00	.....	.....	2,645.00
Student Branches	9,400.00	$ 5,500.00	4,795.26	19,695.26
Technical committees	1,000.00	.....	19,010.00	20,010.00
MECHANICAL ENGINEERING, text	.....	26,000.00	11,640.00	37,640.00
Transactions	.....	28,000.00	11,120.00	39,120.00
Membership List	.....	7,000.00	2,240.00	9,240.00
MECHANICAL ENGINEERING, advertising	.....	15,300.00	20,907.65	36,207.65
Mechanical Catalog	.....	18,800.00	16,545.01	35,345.01
Publications for sale	.....	23,000.00	8,717.34	31,717.34
Retirement fund	2,700.00	.....	.....	2,700.00
Professional services	1,025.00	.....	.....	1,025.00
E.C.P.D.	850.00	.....	.....	850.00
Secretary's office	.....	.....	16,716.00	16,716.00
Accounting	.....	.....	14,150.00	14,150.00
General service	.....	.....	25,810.00	25,810.00
General office expense	.....	.....	16,920.00	16,920.00
Totals	$73,232.00	$123,600.00	$192,220.00	$389,052.00

ESTIMATED INCOME FOR 1939–1940 ADOPTED BY THE COUNCIL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, JULY 10, 1939

Income	Actual 1937–1938	Estimate 1938–1939	Estimate 1939–1940
Initiation and promotion fees	$ 8,928.00	$ 7,000.00	$ 6,000.00
Membership dues	210,656.80	208,000.00	208,000.00
Student dues	15,693.50	18,200.00	18,200.00
Interest and discount	8,732.20	8,100.00	7,600.00
MECHANICAL ENGINEERING, advertising	75,718.74	70,000.00	70,000.00
Mechanical Catalog, advertising	41,453.62	36,000.00	38,000.00
Publication sales	61,786.38	53,500.00	55,000.00
Miscellaneous sales	1,727.61	1,700.00	1,700.00
Contributions, *Journal of Applied Mechanics*	1,775.00	1,000.00	.....
Engineering Index, Inc.	516.52	519.00	519.00
Registration fees	409.00	221.00	221.00
Sale of equipment	262.50	725.00	125.00
Total income	$418,731.87	$397,965.00	$399,365.00
To be added to surplus	12,949.47	9,235.00	10,313.00
Balance for expense	$405,782.40	$388,730.00	$389,052.00

called on Prof. Rudolfo E. Ballester, the 1939 Rice Lecture "incumbent," to affix his signature in the memorial book of Rice lecturers.

Secretary C. E. Davies was then asked by the toastmaster to introduce to the audience for purposes of recognition those members of the Council and past officers sitting at the speaker's table. These ranged from Gale Sullivan, chairman of the San Francisco junior section, to Harte Cooke, vice-president and member for 43 years.

F. T. Letchfield Speaks at Banquet

Charles Bulotti, San Francisco's operatic distributor of machine tools, next favored with a group of tenor solos, after which the group settled themselves for the more serious business of absorbing two addresses on engineering and its contributions to humanity. President Christie outlined the present trends in engineering development, closing with an urgent plea to engineers to explore the frontiers of science, which seem to be opening up in almost limitless vistas in every direction. The address of the evening was given by F. T. Letchfield, member and consulting engineer for Wells Fargo Bank and Union Trust Co. at San Francisco. With very keen analysis, Mr. Letchfield traced in scholarly fashion the engineering connection with the development of our modern civilization, and particularly with the concept of the American individualistic system, and arrived inevitably at the conclusion that every intelligent person must in these times of "loose thinking in high places" place a "premium upon sound intellectual processes."

To quote some high points: "Though the problems facing humanity today are grave and exceedingly complex, the engineer should be the last to contend that they cannot be solved for his profession has often had to do the impossible in its job of increasing the safety and comfort of man's existence. The engineer, however, knows that experience must supplant impractical theories, rational thought replace wishful thinking, facts be substituted for sophistries, and emotionalism yield to intellectual honesty before we may resume permanent forward progress.

"To me engineering is primarily and essentially a rational mental process, a logical method of dealing with the facts of life . . . The engineering profession should consider itself fortunate indeed that the exactions of its work permit no compromise with facts.

"We know that once the American system is allowed to operate freely and normally again with all its old-time vigor the problem of unemployment will be transmuted speedily to one of an acute labor shortage, because wealth and production are synonymous we know that instead of talking of an $80,000,000,000, $100,000,000,000 would not be hard to realize. As engineers, then, let us accept the noblesse oblige which this civilization has placed upon our profession. Let us have the courage to believe that our work has only begun. As citizens, let us reaffirm our abiding faith in all those fundamental principles which have made and which will keep America great."

Engineers' Day

Under the auspices of the San Francisco Engineering Council, Engineers' Day was celebrated Thursday, July 13, at the Golden Gate International Exposition on Treasure Island, San Francisco Bay. The engineers of San Francisco joined with the American Institute of Mining and Metallurgical Engineers and The American Society of Mechanical Engineers, who were holding their national meetings.

At 11:00 a.m., the Honorable Herbert Hoover opened the program with an address on "Engineering Contributions to Human Welfare" in which he outlined the engineering contributions which increase social and economic standards and which, though they raise some social problems, frequently provide solution to other more important problems.

The session broke up for individual visits to the very many interesting exhibits at the Fair. In the evening a dinner was held at which Robert Sibley, Fellow A.S.M.E., presided. He was introduced by S. M. Dows, Mem. A.S.M.E., Chairman of the San Francisco Engineering Council. After welcoming addresses by representatives of the President of the Exposition and the State Commission, Mr. Hoover was again called upon. He discussed the standing and responsibilities of the profession and asked particularly that the older engineers should be more diligent in their interest in the young engineering graduates. Particularly, he asked that these young men be taken into industry and given some form of work, even though it be common labor. In closing, he pointed to the great satisfaction which members of the engineering profession had in holding, as it does, command over great forces and the ability to bend them to human use.

The 1939 Calvin W. Rice Lecture was then presented by Prof. Rodolfo E. Ballester, Director of Department of Irrigation of Argentina. The subject was "Some Economical and Technical Aspects of Argentina." Professor Ballester's address appears in this issue of MECHANICAL ENGINEERING, pages 599–604.

A.S.M.E. Tour to 1939 Semi-Annual Meeting, San Francisco, Enjoys Hospitality of A.S.M.E. Sections En Route

A NUMBER of A.S.M.E. members and guests took advantage of a special tour to the Pacific Coast to attend the 1939 Semi-Annual Meeting at San Francisco, July 10–15. The group that left New York on the afternoon of June 28 increased in numbers as others joined it at various points en route westward.

At La Salle, Colo., where the first stop was made for sight seeing, the party was greeted on the morning of June 30 by Robert H. Throne secretary of the A.S.M.E. Colorado Section, whose friendly hospitality and knowledge of points of interest added greatly to the enjoyment of the travelers.

Colorado Section Host

Following luncheon at the Stanley Hotel the party went by bus to Milner Pass, on the Continental Divide, and along Long Ridge, where many views of mountain scenery were enjoyed. In the evening members of the A.S.M.E. Colorado Section acted as hosts to the tour party, and provided as a speaker Porter J. Preston, who will be in charge of the Colorado-Big Thompson project, and who described the plan of development of the project and its cost with the aid of a model and a large number of charts and drawings. As a result of this project waters now flowing eventually into the Pacific Ocean will be diverted into the Mississippi valley for purposes of irrigation in Colorado. Present at the meeting was F. O. Stanley, 92-year-old inventor of the Stanley "Steamer," who made a gracious address to the audience.

On Saturday July 1 a bus ride took the visitors to Rocky Mountain Park through old mining districts, including Central City, to the summit of Mt. Evans, altitude 14,259 ft. Views of Pike's Peak, 75 miles distant, and of the range and plains were enjoyed.

Returning to Denver, the party left in the late afternoon for Salt Lake City, where it arrived the next morning in time on Sunday morning to witness a broadcast of choir and organ in the Mormon Tabernacle and to visit the State Capitol and Utah Museum. Following luncheon, the Bingham Mine, largest open-cut copper mine in the world, was visited en route to Salt Aire Beach, famous resort on Great Salt Lake.

Arriving at Lund, Utah, early Monday morning, the party enjoyed a two-day tour of Cedar Breaks, Bryce Canyon, and Zion Park, and a day at Boulder Dam where Irving C. Harris personally escorted the party.

Reaching Los Angeles on July 6 when the schedule called for a two-day stop, the party visited the California Institute of Technology and listened to a lecture on the grinding and polishing of the 200-inch mirror for the Mt. Palomar telescope. President Christie joined the party at luncheon and remained with it during a visit to the Huntington Library and Art Museum.

The visit to Los Angeles included a dinner at the Biltmore Bowl with members of the A.S.M.E. Los Angeles Section and a motor trip about the city and its environs and motion-picture areas, where the grounds of Warner Bros. were visited.

Two Days at Yosemite

The two days prior to arrival at San Francisco were spent at Yosemite, and included visits to Manpora Grove, where the "big trees" were seen, and the floor of the valley.

Monday morning the party reached Berkeley where George H. Raitt, new chairman of the A.S.M.E. San Francisco Section, and several members of his executive committee boarded the train to welcome the party and escort it to the Fairmont Hotel, headquarters for the Meeting. At the Market Street ferry, Warren H. McBryde, recently nominated for office of president A.S.M.E., and others were on hand to welcome the party to San Francisco.

(A.S.M.E. News continued on page 638)

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Changes in Patent System Before Congress

A SERIES of bills proposing simplification and speeding up of the procedure by which patents are issued by the Patent Office have been introduced in Congress. These bills embody suggestions made by Commissioner of Patents Conway P. Coe in testimony before the Temporary National Economic Committee and are supported, in general, by the patent bar. Since very little opposition has been voiced, it is hoped to pass some, at least, of the bills before Congress adjourns.

The principal changes proposed are:

(1) Reclassification of Patent Office records by a force of 25 additional examiners whose entire time shall be devoted to this task. Modernization of the classification system, now admittedly antiquated and confusing, is expected to expedite the examination of future patent applications and thus conserve the time of both examiner and applicant (H.R. 6721).

(2) Reduction in the time allowed for public use of an invention before applying for a patent from two years to one year (H.R. 6872).

(3) Simplification of the present interference practice, which decides which of two conflicting applications shall be granted, by referring the matter to a three-man board of interference examiners and issuing a patent immediately in consonance with their decision. Thereafter the losing party can, if he wishes, appeal the matter but the present long delay in issuance whenever such appeal is taken is eliminated (H.R. 6873).

(4) Reduction of the time for paying the final patent fee from six to three months after notice that the application has been approved. The Commissioner is given discretion to extend this time an additional year if justification for the delay is demonstrated (H.R. 6874).

(5) Limitation of the time for copying claims into an application from prior patents to those issued within one year, rather than two (H.R. 6875).

(6) Reduction in the allowed time for responding to Patent Office communications from the present six months to not less than 30 days, at the discretion of the Commissioner (H.R. 6878).

(7) Termination of the life of a patent at 17 years after date of issue or 20 years after date of application, whichever is shorter (S. 2688).

(8) Setting up a single Court of Patent Appeals to which shall be referred all appeals from decisions of U. S. District Courts regarding patent cases (S. 2687).

These two Senate bills were approved by the Senate Patents Committee on July 6, and the six House bills were passed by the House on July 6.

Utility Study Issued

A statistical study of the operations of 385 privately owned electric-utility companies, comprising about nine tenths of the industry, for the calendar year 1937 has been published in two volumes by the Federal Power Commission. These two volumes are available at $2 per set.

The Commission is also preparing to publish a National Electric Rate Book showing the residential, commercial, and industrial electric rates charged by all utility companies in the United States, whether privately or publicly owned. This material will be bound in a loose-leaf binder so that subsequent revisions can easily be substituted to keep the volume up to date. The price will be $15, including any supplements that may be issued up to December 31, 1939; subsequent supplements will cost $7.50 per year. Separate issues will also be available which will cover individual states at prices from $1 to $2 each, depending on size.

Men and Positions Available

Engineering Societies Employment Service

MEN AVAILABLE[1]

MECHANICAL ENGINEER, master's degree, June, 1939. Desires position as assistant in research or designing work. Experience in development of materials-testing machine. Good draftsman. Me-332.

GRADUATE MECHANICAL ENGINEER, 25, single. Experienced in designing, drafting, and testing of rotary gas burners, steam turbines, air filters, and blowers. Systematizing and bills of material. Desires position as assistant designer. Me-333.

INDUSTRIAL ENGINEER, 29; employed. Six years' experience development and application of wage incentives, time and motion study, cost and production control, labor relations. Interested primarily supervisory or executive position. Free to travel. Me-334.

MECHANICAL PLANT-BETTERMENT ENGINEER, M.I.T. graduate. Twenty years' experience utility and industrial power-plant supervision, operation, testing, heat-balance computations, estimating, design, analysis. N. Y. Professional Engineers' License. Single, free to travel. Me-335.

1939 GRADUATE MECHANICAL ENGINEER, honor student who defrayed most of his own college expenses, desires position in production with medium-sized company. Me-336.

MECHANICAL ENGINEER, 39. Broad experience in stress analysis, lubrication, vibrations, welding; 12 years with present employers. High inventive ability. Languages. Widely traveled U. S. A. and abroad. Desires position New York Metropolitan district. Me-337.

MECHANICAL ENGINEER, 21; single; 1939 graduate of accredited engineering college, adaptable, versatile, member Sigma Tau, 1 year engineering experience. Desires position offering future advancements or to attend company training school. Me-338.

MECHANICAL ENGINEER, 23, Polytechnic Institute of Brooklyn, 1938. Machine-shop experience. Interested in designing or testing. Will go anywhere. Me-339.

MECHANICAL-METALLURGICAL ENGINEER, 26, single, Stevens graduate. Twenty months' extensive and varied training course with prominent company; 2 years' broad metallurgical application. Now employed, desires connection affording opportunity for greater progress. Me-340.

SALES ENGINEER, young mechanical engineer, 3 years' experience sales engineering, sales promotional and missionary work. Developed sales steam specialties with industrials and dealers. Employed, desires sales position with manufacturing concern. Me-341.

MECHANICAL ENGINEERING GRADUATE, 22, Newark College of Engineering. Experienced in construction engineering. Interested in power-plant-equipment drafting, design, and layout; also supervision work in building construction. Willing to travel. Me-342.

GRADUATING MECHANICAL ENGINEER, 22; single. Two years' experience as undergraduate assistant in Southern university teaching drafting and descriptive geometry. Desires graduate teaching position or sales-engineering training. Me-343.

GRADUATE MECHANICAL ENGINEER, 22, excellent college record. One year of drafting and designing experience in heat exchangers, steam condensers, and small machine parts. Position with engineering future desired. Me-344.

MECHANICAL ENGINEER, 8 years' experience (U. S. and abroad) in design, plant layout, erection, production, operation, maintenance. Master's degree, knowledge French, German, Spanish. At present employed, seeks promising junior executive position. Me-345.

MECHANICAL ENGINEER, 45, married. Ten years' management and operation gas properties and pipe-line projects; 8 years' experience valuation, reports, investigations and appraisals of public-utility and industrial properties. Me-346-331-D-3-San Francisco.

POSITIONS AVAILABLE

MACHINE-TOOL DESIGNER with at least 10 years' experience in machine-tool field. Work will be on horizontal boring and special multiple drilling machines. Salary, $250 a month to start. Location, Ohio. Y-4365-R692-C.

DESIGNER with at least 6 years' experience on drafting board in tool, die, and steel product designing. Salary, $250–$275 a month. Location, Middle West. Y-4377C.

MECHANICAL OR INDUSTRIAL ENGINEER with about 10 years' experience, preferably in ferrous or nonferrous rolling mill. Duties will be to study machines, operations, and methods with view toward improving equipment, operations, and processes in brass mill producing sheet, tube, rod, and wire. Salary, $3500 a year. Location, New England. Y-4380.

GRADUATE MECHANICAL ENGINEER, 35–45, with experience in rubber industry. Company will consider research engineer with wide back-

[1] All men listed hold some form of A.S.M.E. membership.

(*A.S.M.E. News continued on page 640*)

HAGAN AUTOMATIC COMBUSTION CONTROL

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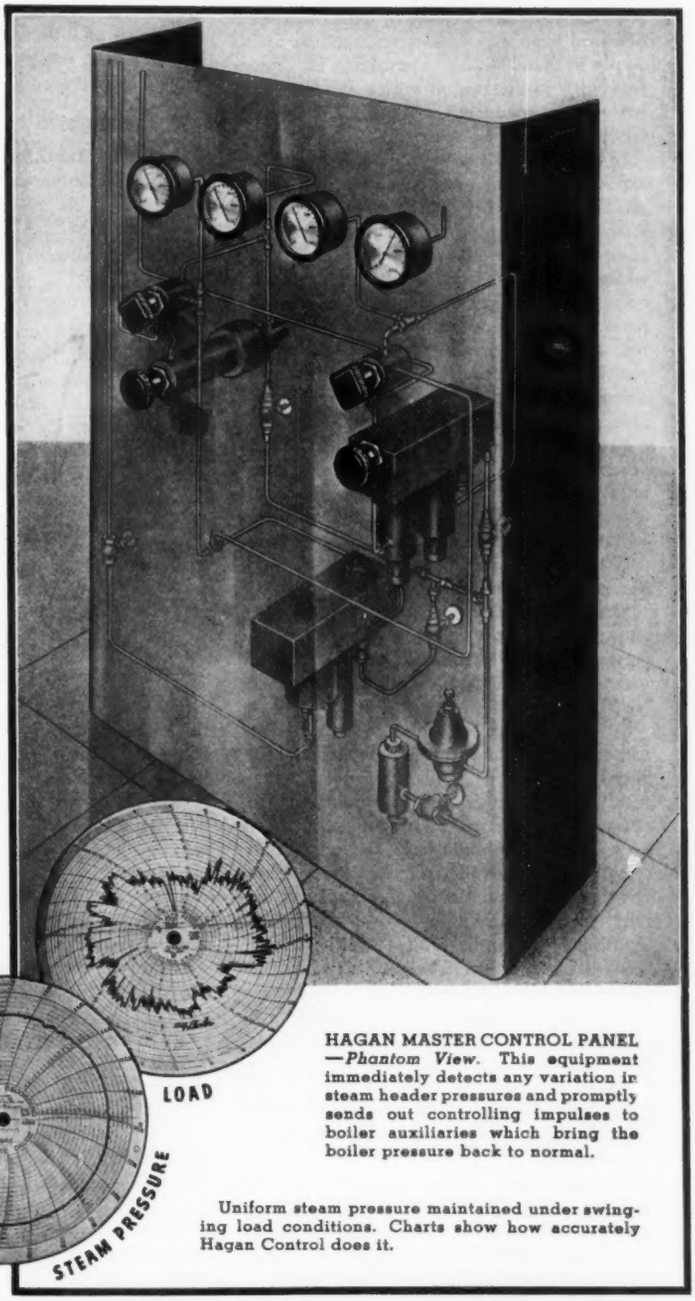

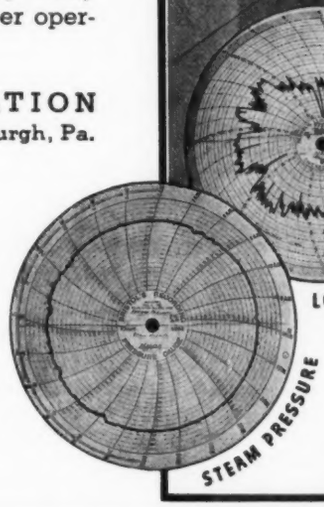

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ground in all types of plant engineering in any large manufacturing company. Salary, $300–$350 month. Location, Middle West. Y-4391C.

RESEARCH ENGINEER to investigate effect of many interrelated variables in grinding and other machine-tool operations, and to help develop improvements in machine tools. Should be a scientist, 5 to 15 years out of college, with leaning toward machinery, as company wishes to go deeply into such things as the metallurgy of surfaces finished under different conditions, and to make use of the best scientific equipment and methods to solve practical problems. Many of the data will be obtained from experiments on machine tools. Apply by letter giving information in connection with investigations which the candidate has already conducted. Location, New England. Y-4403.

MECHANICAL DESIGNER with considerable experience in design and development of small mechanisms. Work will be in connection with design of radio mechanisms. However, company will consider man with experience in adding machines, comptometers, typewriters, or similar machines involving small moving parts. Should know manufacturing processes, tolerances, etc. Experience in die casting and plastic molding as well as screw-machine; and stamping requirements would also be desirable. Location, Middle West. Y-4404C.

FACTORY MANAGER, 35–45, with at least 5 years' experience in a similar capacity, primarily in assembly plant; i.e., electrical appliance, radio, or other novelty plant. Company employs 400 union workers. Salary, $3000–$5000 year. Location, New York Metropolitan area. Y-4405.

MECHANICAL ENGINEER for investigation and development work. Must have had experience in small, intricate parts, especially patents of all kinds. Location, New York, N. Y., Y-4407.

SALES ENGINEER, about 30, who has had a technical education in one of the good colleges. Should have about 5 years' experience, preferably with manufacturer of industrial instruments. Experience with fluid flowmeters very desirable. Should have ability not only to sell mechanical and electrical instruments, but to promote sales through company's district representatives. Salary, $175–$250 month. Location, East. Y-4409.

SALES ENGINEER, not over 40, to sell lubricating specialties in Connecticut. Must have 5 to 10 years' experience in direct selling of tangibles to industrial plants. Must own car. Small salary plus expenses and commission. Y-4423.

FACTORY MANAGER, graduate mechanical engineer with at least 10 years' machine-shop experience operating plant employing approximately 1000 men. Salary, $5000–$7000 year. Location, New York State. Y-4434.

SUPERVISOR, preferably single, to take charge of production department handling, planning, routing, and scheduling of manufacturing orders through the factory. Engineer with experience in production work in airplane-manufacturing companies preferred. Three-year contract. Apply by letter giving full details of education, experience, past compensation, etc., and enclosing recent photograph. Location, China. Y-4436.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after August 25, 1939, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Reelection; Rt = Reinstatement; Rt & T = Reinstatement and transfer to Member

NEW APPLICATIONS

For Member, Associate, or Junior

BITTERMANN, F. J., Wilmington, Ill.
BOISE, FREDK. WM., Colonial Park, Pa.
BUFORD, E. H., Anniston, Ala. (Rt)
CHATTERJEE, B., Benares, India
CHEASLEY, THOMAS C., Kansas City, Mo.
CLOUGH, ROY E., Berkeley, Calif.
CONRAD, JOSEPH D., Springfield, Pa.
DAUGHERTY, E. S., Philadelphia, Pa.
DOUGLAS, EDW. B., Manville, N. J.
ELLIS, H. ALFRED, Fort Wayne, Ind. (Rt)
FOWLER, G. L., Kokomo, Ind.
FRIEDRICH, W. G., Newfoundland, N. J.
GRAVES, E. H., Richmond, Va.
HACKNEY, E. W., Ft. Wayne, Ind.
HAGUE, FLOYD T., Drexel Hill, Pa.
HAINES, RICHARD A., Bethlehem, Pa.
HARRISON, HERBERT L., Chicago, Ill.
HOLMES, RICHARD B., Indianapolis, Ind.
HUNTING, RONALD W., Philadelphia, Pa.
INGRAHAM, ARTHUR K., San Francisco, Calif.
JOHNSON, ROBERT L., San Francisco, Calif.
KLINE, CLEMENT L., New Castle, Ind. (Rt)
KOEHLER, OSCAR E., Greenfield, Mass.
KRUCHEN, WM. S., Catasauqua, Pa.
MUNDY, JAS. T., Atlanta, Ga.
PATTERSON, JAS. L., Toronto, Ont., Can.
RAES, JOS. K., Boston, Mass.
ROBINSON, ALBERT W., Oak Park, Ill.
SIECKE, KURT H., Port Angeles, Wash.
SETTY, K. S., Vepery, Madras, India
SMITH, WINFIELD P., San Francisco, Calif.
SPOTTS, M. F., Baltimore, Md.
STEPHAN, ERICH R., New Orleans, La.
STEWART, JAMES C., Dallas, Texas
SWENSON, JOHN D., Amherst, Mass.
TATE, G. H., Holland Landing, Ont., Can. (Rt & T)
WEAVER, EARL M., Houston, Tex.
WILLIAMS, T. C., Vineland, N. J.
WILLIAMS, WM. A., Philadelphia, Pa.
WRIGHT, L. AUSTIN, Montreal, Que., Can.
YARBER, G. W., San Francisco, Calif.

CHANGE OF GRADING

Transfers to Member

ESERKALN, THEO. F., Milwaukee, Wis.
ESHELMAN, JOS. W., Birmingham, Ala.
JOHNSEN, GEO. J., Jersey City, N. J.
TRUEDSSON, GOSTA R., West Hartford, Conn.

SALESMAN, preferably single, 28–30, graduate mechanical engineer with power-plant and sales experience. Salary, $150 month. Location, East. Y-4437.

SALES ENGINEER, graduate mechanical engineer with 10 or 12 years' experience pricing, selling, and installing power-transmission machinery. Apply by letter giving full details of education, experience, salary earned, married or single, etc. Location, Middle West. Y-4441C.

DESIGNER, mechanical engineer with considerable specialized experience in high-pressure oil hydraulic systems, valves, controls, and cylinders for machine tools, presses, etc. Salary, $250–$300 month. Location, Middle West. Y-4443-R-698C.

GRADUATE MECHANICAL ENGINEER, 30–40, with experience in handling men in machine shop, on erecting floor or similar work. Must be mechanically inclined so that he can analyze difficulties in design, and more particularly, maintenance work. Engineer who has had, in addition to machine-erecting experience, experience in air-conditioning and charcoal-adsorption apparatus, would be very desirable. Opportunity. Salary, $3000–$4000 year. Location, South. Y-4452.

MACHINE DESIGNER, graduate chemical engineer, 25–40, with practical shop and process-design experience. Salary, $275 month. Location, Middle West. Y-4455C.

A.S.M.E. Transactions for July, 1939

THE July, 1939, issue of the Transactions of the A.S.M.E. contains the following papers:

TECHNICAL PAPERS

Discharge Temperatures From Pulverizers, by Ollison Craig

Atomization of Oil by Small Pressure-Atomizing Nozzles, by E. B. Glendenning, A. R. Black, L. H. Ventres and W. A. Sullivan

High-Temperature Steam Experience at Detroit, by R. M. Van Duzer, Jr., and Arthur McCutchan

The Vectorscope, by G. J. Dashefsky

Problems and Trends in Centrifugal-Machine Applications, by J. S. Pecker

Motive-Power Characteristics and Lightweight Equipment, by R. Eksergian

DISCUSSION

On previously published papers by Messrs. J. N. LeConte; L. Allievi; E. B. Ball; L. H. Kessler; G. J. Bischof; J. R. Jackson; L. C. McCabe; S. Rosenzweig; F. L. Haushalter; and P. T. Norton, Jr.